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SINGLE-FREQUENCY REPEATER

FINAL REPORT

by

G. Winram, H. Moore, M. P. Rosenthal

May 1968

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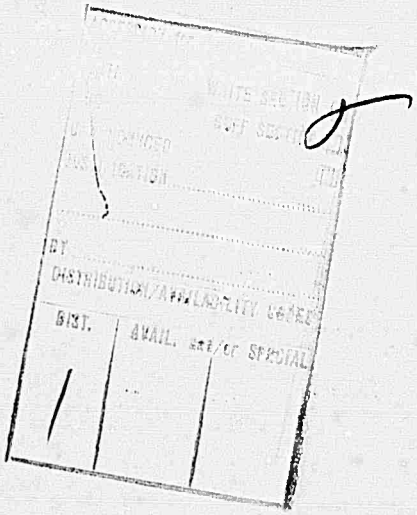

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SINGLE-FREQUENCY REPEATER

FINAL REPORT
15 June 1967 to 15 March 1968

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ABSTRACT

A study has been made of the feasibility of using a Single-Frequency Repeater for extending the range (voice) of the AN/PRC-25 Radio Set. A feasibility model has been designed using the principle of chopped, delayed voice; constructed; and tested in a limited manner. Test results are presented, as are general description and operating instructions.

The results of the work done so far indicate that Single-Frequency Repeating can be used to repeat a voice-modulated, FM, RF signal and still retain some measure of intelligibility at the Receiving Terminal.

The distance to which the effective range of a pair of AN/PRC-25 Radio Sets can be extended, using the model Repeater, is not yet known, mostly because of insufficient performance measurements. Considerable extension is unquestionably possible if the modified AN/PRC-25 Retransmitter is replaced with a suitable Retransmitter.

Some improvements to intelligibility can also be made, as evidenced by the limited experiments already carried out. One, for example, would be to implement synchronous audio blanking at the Remote Receiver during idle (non-transmit) times, thus eliminating the inevitable Receiver noise. Another would be to improve the quality of the audio input to the Retransmitter; it presently suffers from severe distortion. For example, an AGC amplifier used in place of the existing limiting arrangement would certainly offer significant improvement. Still other improvements could occur from optimizing the chopping rate, Guard Band, and the RF responses at both the Repeater and Remote Receivers.

The improvement to intelligibility resulting from implementation of one or more of the foregoing is difficult to estimate at present. A much better assessment could be made after a full system analysis has been performed.

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TECHNICAL DISCUSSION

1. PURPOSE

The purposes of this program were:

- To design, using chopped and delayed voice,* construct, and test a feasibility model RF Single-Frequency Repeater for use in extending the working range of Radio Set AN/PRC-25, especially where range is limited due to obstacles in the transmission path;

- To furnish test results, and recommendations based upon these results.

2. REPEATER GENERAL DESCRIPTION

The model repeater is intended to facilitate establishment of feasibility of a Single-radio-frequency repeater principle based on alternate reception and retransmission, using a voice-delay circuit between receiver and retransmitter. Fig. 1 illustrates the overall principle.

The model consists of three major units:

- Receiver, Retransmitter, Antenna, and Electronic Control Circuits, all packaged in a portable wooden cabinet, Figs. 2, 3, and 4.

- A commercial-type Stereo Tape Deck, used as the delay device, packaged in its own cabinet.

- A DC-to-AC Converter to supply variable-frequency power from a storage battery to the Tape Deck. The Converter is self-contained and portable.

Both the Receiver and Retransmitter are modified AN/PRC-25 Radio Sets. No attempt was made to use a single AN/PRC-25, although it might be possible.

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* This investigation of interrupted speech is based on the paper by G.A. Miller and J.C.R. Licklider, "The Intelligibility of Interrupted Speech," Jour. Acoustical Soc. Am., V. 22 No. 2, March 1950, pp. 167-173.

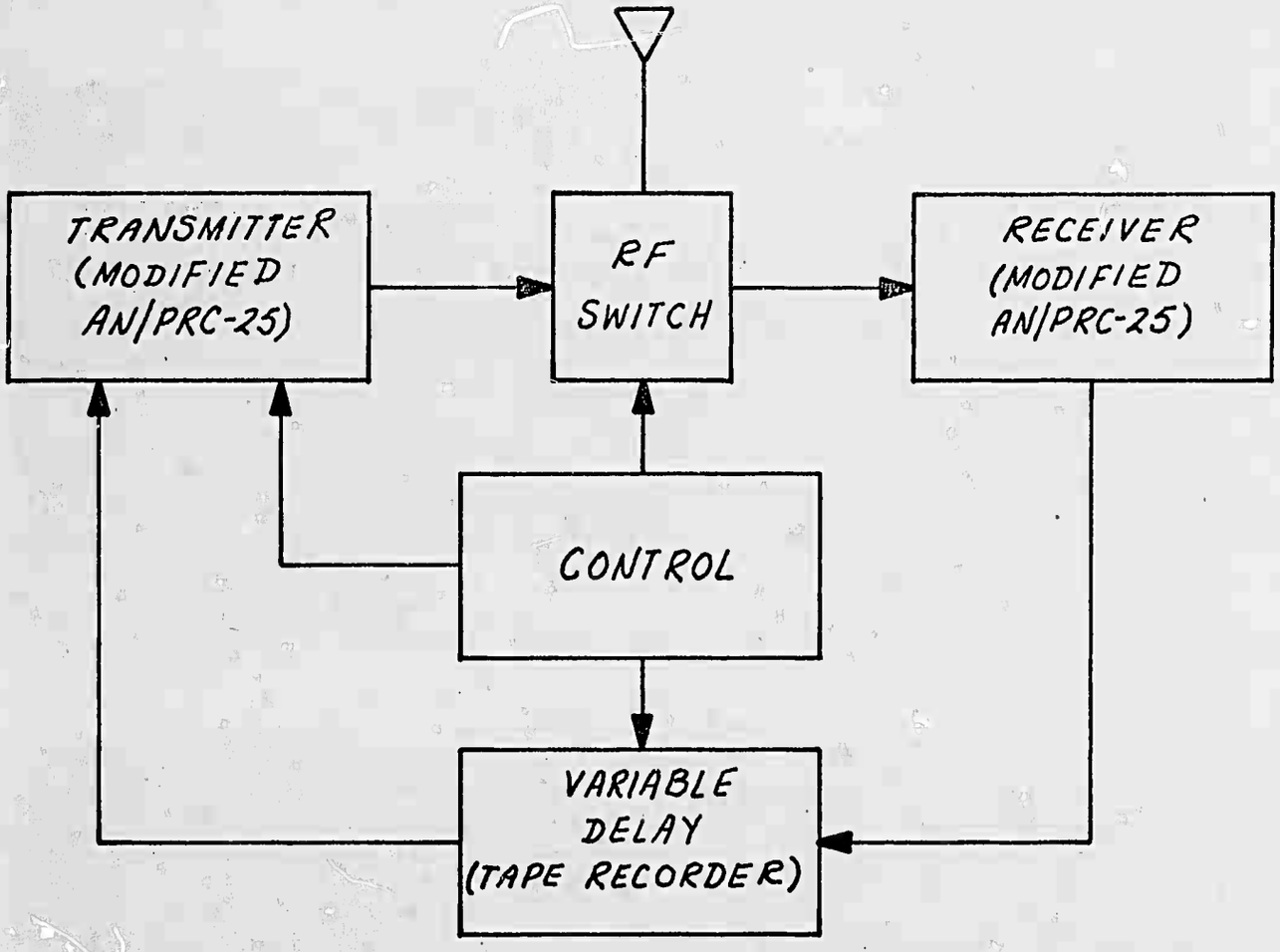

Figure 1. Overall Block Diagram

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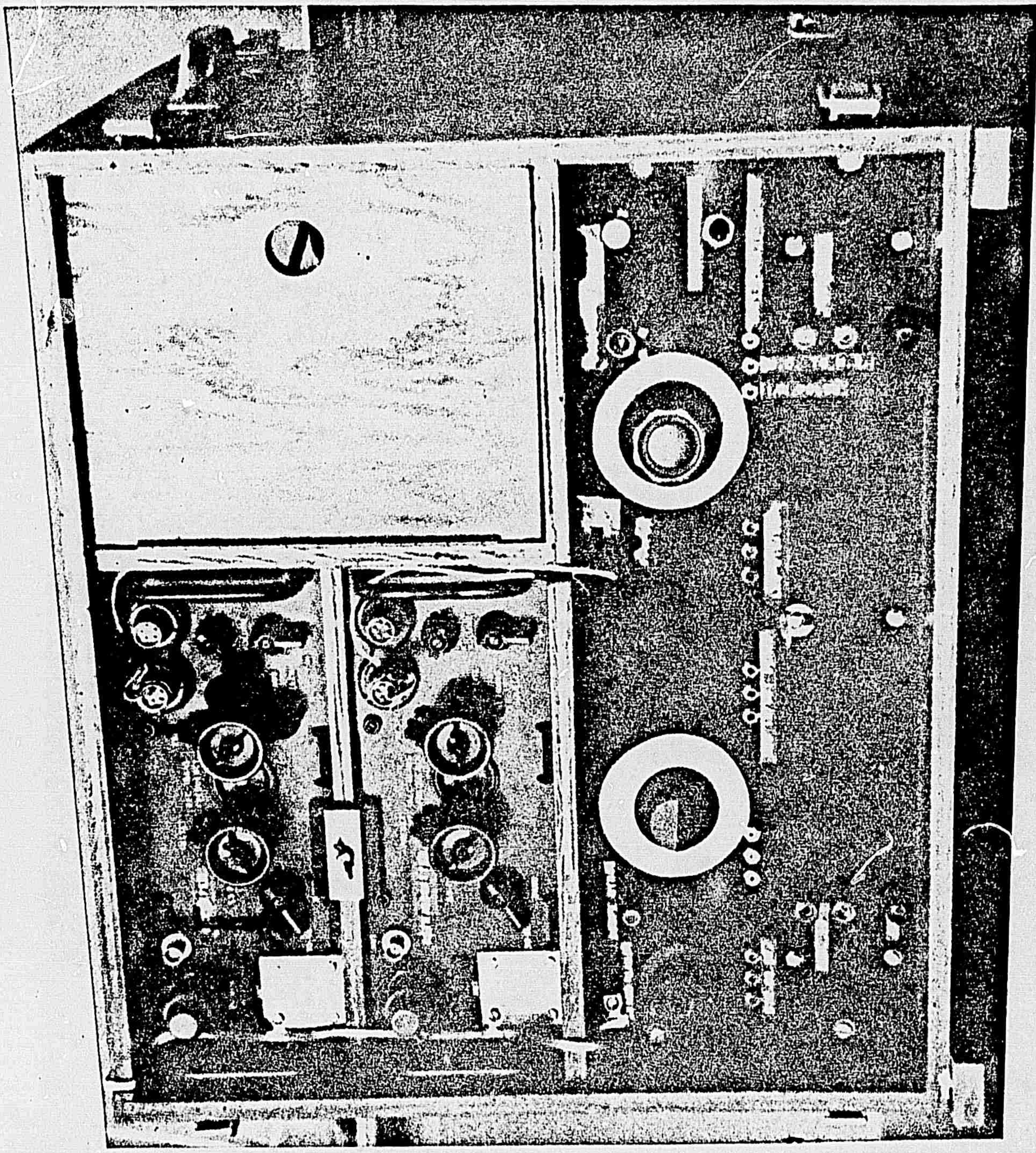


Figure 2. Single-Frequency Repeater, Front View

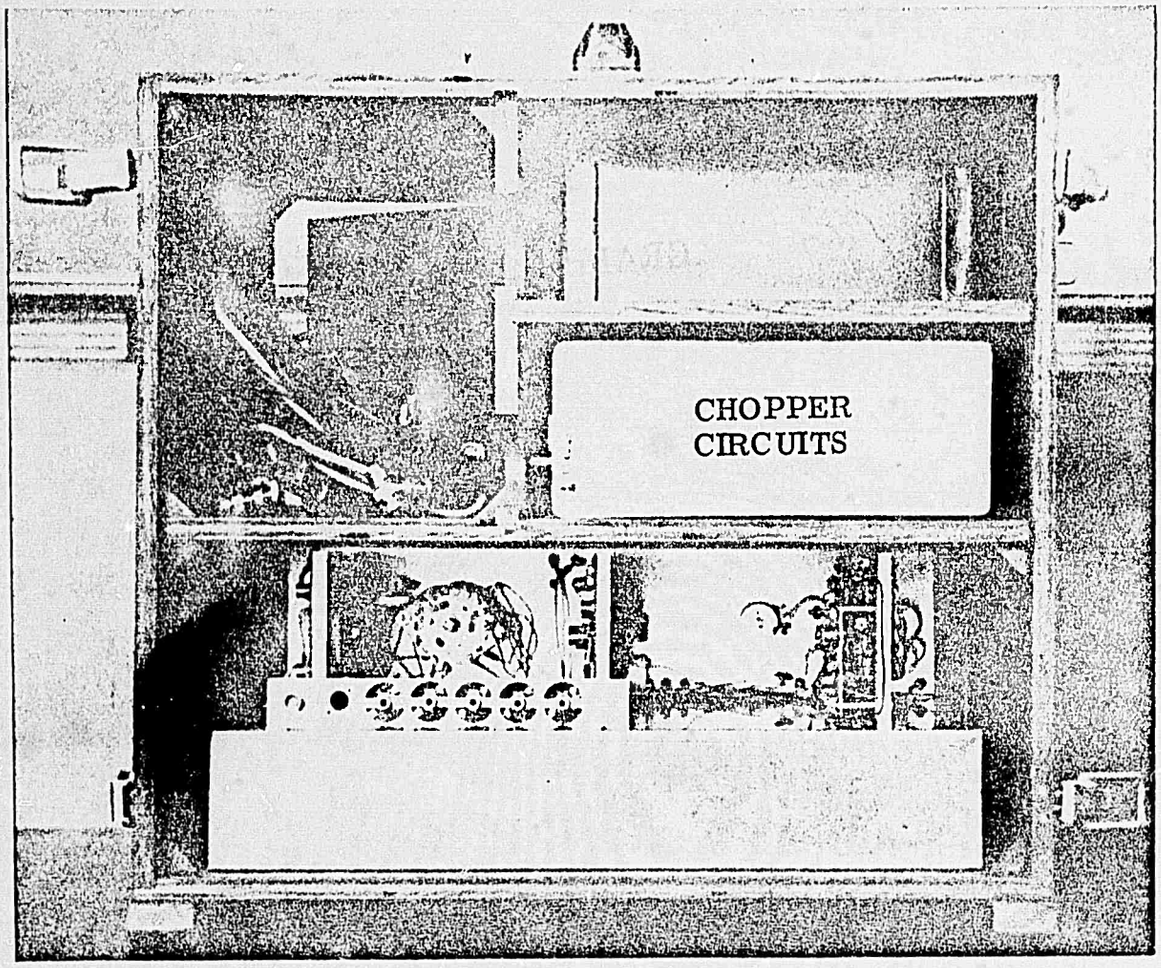


Figure 3. Single-Frequency Repeater, Rear View

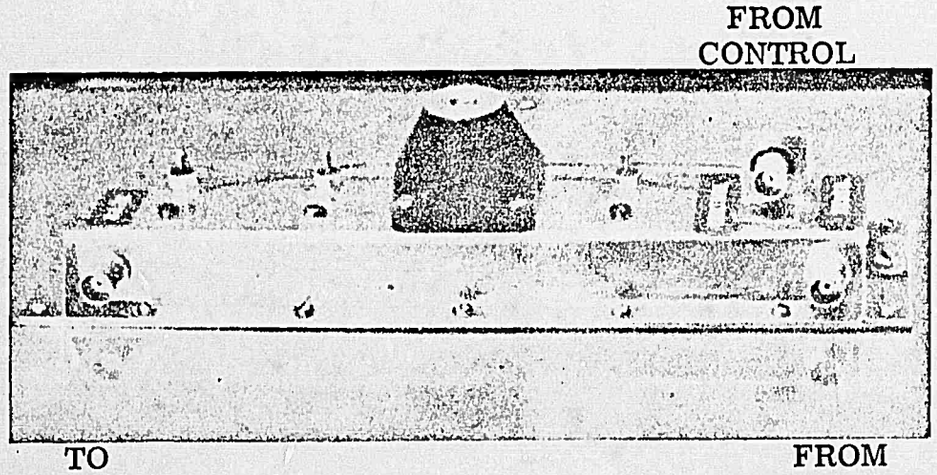


Figure 4. Antenna Switch

A single antenna is used, switched from Receiver to Retransmitter, and vice versa, in synchronism with Retransmitter power. The received audio is delayed by one half the switching period, then fed to the Retransmitter.

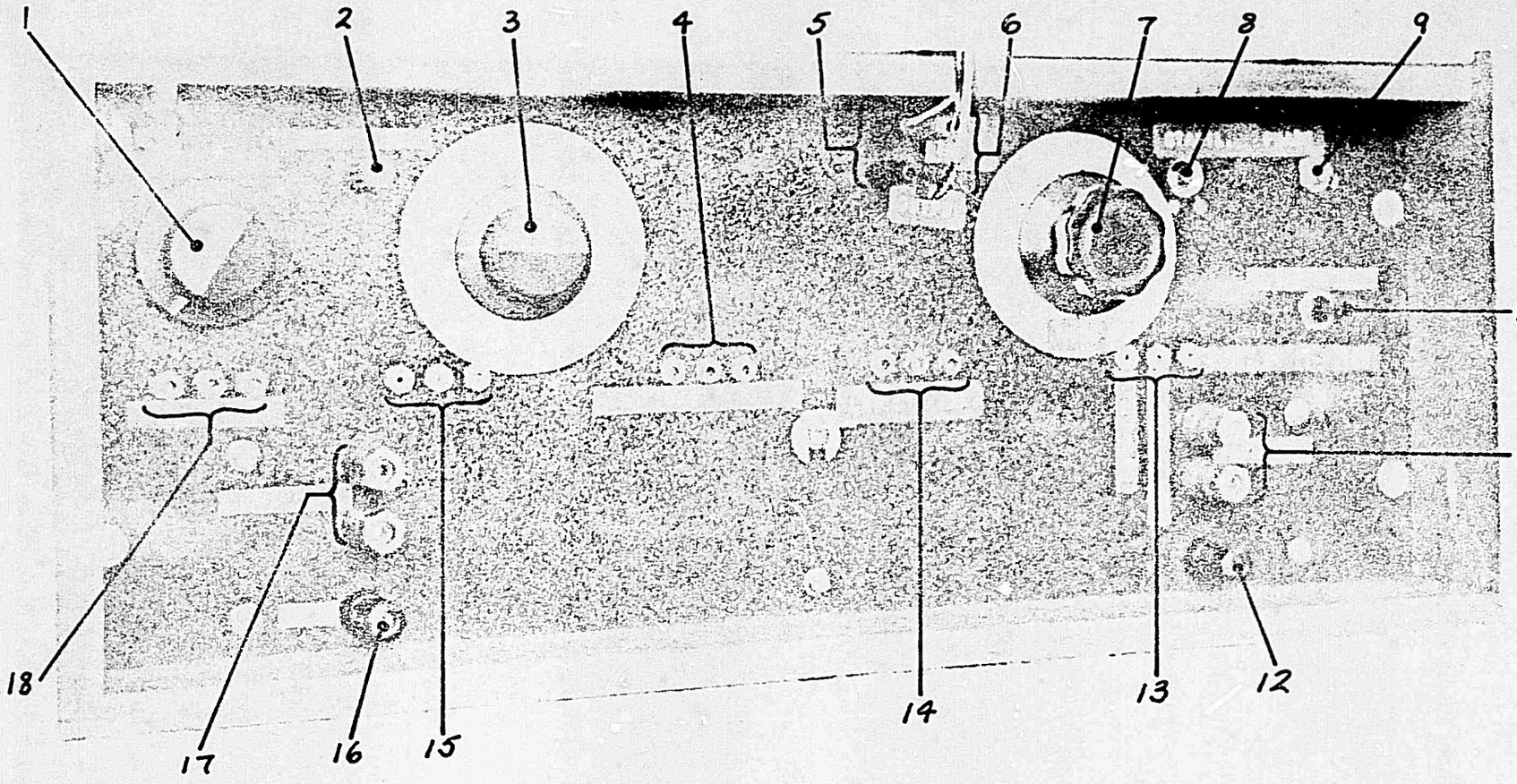
Except for the Antenna Switch and the Retransmitter pulsing circuits, the Control Circuits are all card-mounted on a chassis and panel. The Antenna Switch is mounted as shown in Fig. 4, while the pulsing circuits are built onto the battery pack of the Retransmitter.

The MODE switch (7, Fig. 5) on the Control Panel enables five functions, including OFF, as follows:

- Receiver - In this position only the Receiver is operative, with Antenna connected, in practically conventional form. Here the Receiver can be used both as a transceiver for two-way communication, and to check out the first part of a repeater circuit, i.e., to receive conventionally from an originating transmitter. This latter function enables signal-to-noise ratio (SNR) adjustments for just this part of a repeater circuit.

- Transmitter - In this position the Retransmitter is connected directly to the Antenna, its power relay is "on", and the added electronic power-control switches are "on". The Retransmitter will radiate if its own ON-OFF Switch is ON, and voice can be sent if a handset is connected. This mode enables setting up the second part of a repeater circuit (retransmission), as a valid and steady carrier can be sent to a remote receiver; also, this mode enables precalibrating modulation deviation.

- Standby - In this position only the minimum services remain connected, to conserve power. Power for the Tape Deck and master waveform generator remain "on".



1. GUARD BAND Control (R1, Fig. 7)
2. SCOPE SYNC. Connector (Fig. 7)
3. FREQ. Control (R10, R12, Fig. 7)
4. Blue Test Points* (Fig. 8)
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6. INPUT Connectors (Red, Green, Fig. 6)
7. MODE Switch (S1, Fig. 6)
8. STABILITY Indicator (I1, Fig. 9)
9. PHASE Control (R21, Fig. 9)
10. SYNCHRONIZER Switch (S1, Fig. 9)
11. POS. 15 V Connectors (+ No. 1, + No. 2, Fig. 6)
12. Ground Connector
13. Yellow Test Points* (Fig. 9)
14. Green Test Points* (Fig. 9)
15. White Test Points* (Fig. 6)
16. GND Connector (Fig. 6)
17. NEG. 15 V Connectors (- No. 1, - No. 2, Fig. 6)
18. Red Test Points* (Fig. 7)

* All Test Points read in sequence (1, 2, 3) from Left to Right.

Figure 5. Control Panel

- Repeat - In this position all circuits function, including the servo lock indicator. The Repeater is ready for operation in this position, providing the Receiver, Retransmitter, and Tape Deck power switches are ON.

Only four other controls are mounted on the Control panel; of these, only the Master Oscillator (chopping) FREQ. Control and the SYNCHRONIZER Switch are used frequently. The control functions are as follows:

- Master Oscillator FREQ. (3, Fig. 5) - Provides continuously variable control of the chopping frequency from 10 - 100 Hz, calibrated.

- GUARD BAND Control (1) (Duty Cycle of Switching Waveform) - Enables minimization of the effects of transients, Tape-Deck instability, misalignments, etc.

- SYNCHRONIZER Switch (10) - Although synchronization is automatic for the tape-delay servo (which assures proper delay for the voice channel according to the chopping rate selected), there are several frequencies at which synch can be obtained. This momentary switch provides the means for obtaining synch at that frequency offering minimum servo-loop error. The STABILITY Lamp (8) works in conjunction with this switch, indicating proper synch (lockup).

- PHASE Control (9) - Provides the master delay setting for the servo system. Once set, usually needs no resetting in normal use.

Five groups of three test points each, plus a SCOPE SYNC Terminal (2) are also provided on the panel. Their functions are described later.

Power for the Tape Deck electronic and drive circuits is derived from a 12 V storage battery (typical automobile battery). The power source for the Electronic Control Circuits consists of four BA-386 15 V dry batteries, the same type used to power the AN/PRC-25. These batteries are

contained within the wooden cabinet. As options, either external batteries or two AC power supplies can be used. Reasonable field-trial battery life is about two days; more, if the STANDBY mode is used as often as possible.

3. DESCRIPTION OF CIRCUITRY AND THEORY OF OPERATION

3.1 CONTROL CIRCUITS

The Control Circuits are assembled almost entirely on three circuit boards mounted on a chassis and panel. The main function of the control system is to delay voice samples received during the non-transmitting periods and make them available to modulate the Retransmitter, which is turned on for comparable periods following the voice samples. Other functions are to pulse the Retransmitter on and off at a preset but adjustable rate, and to appropriately switch the Antenna from the Receiver to the Retransmitter. All these functions must be carefully synchronized to avoid transients due to any overlap.

The overall Repeater block diagram is shown in Fig. 6. Only the major blocks are shown; block details are described below.

3.1.1 Master Waveform Generator (See Fig. 7.)

This unit makes up a circuit board (Board #1) in its own right. The master oscillator, which functions via different auxiliary circuits, is an RC-feedback type, using a dual potentiometer (R10, R12) as frequency control and a No. 1869 lamp bulb (I1) as automatic level regulator. Frequency and level stability are sufficient for the purpose. Stability is necessary, as frequency variations would disturb the servo system that depends on the oscillator, and amplitude variations would affect operation of the Schmitt Triggers used in setting the Guard Band and other squaring functions.

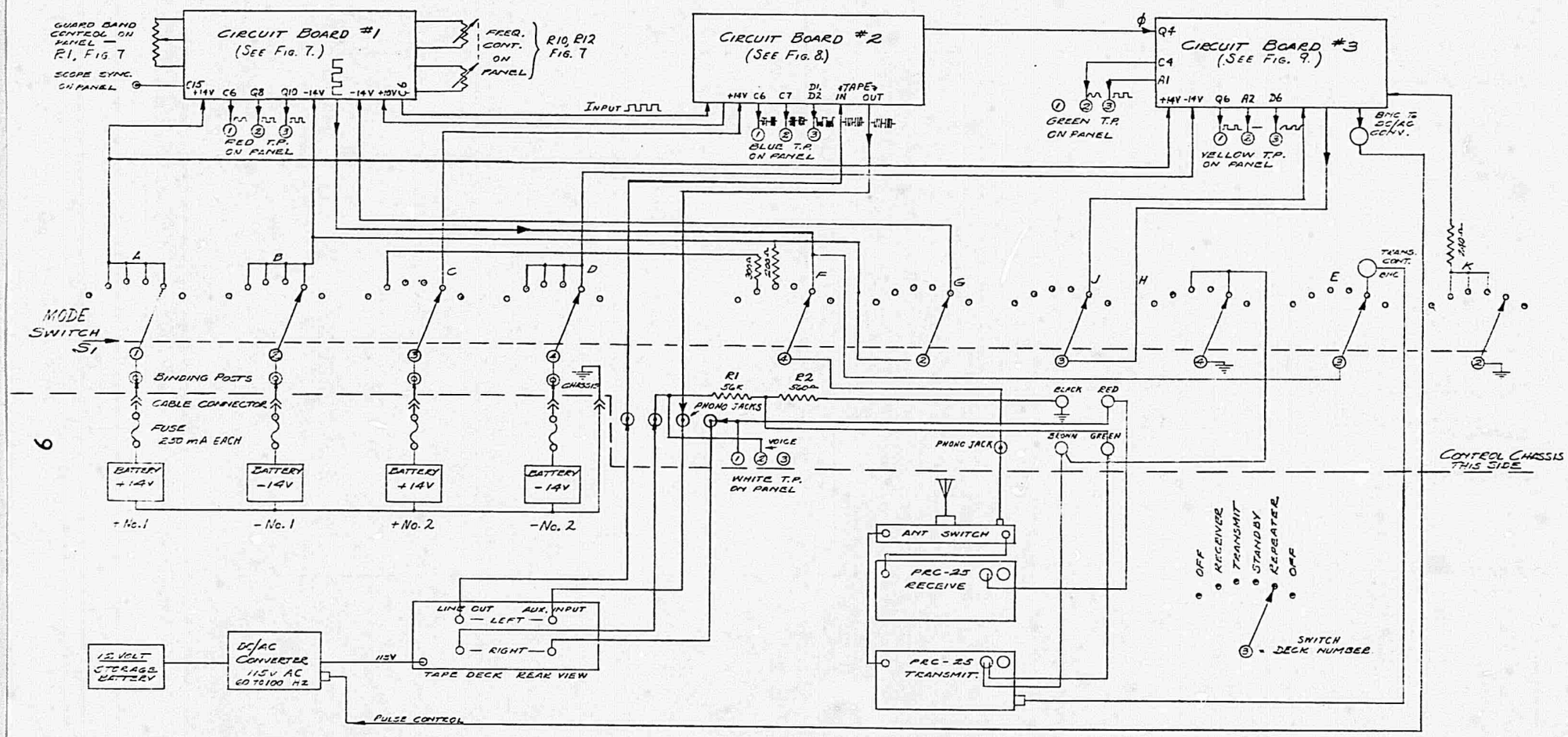

Figure 6. Repeater Overall Wiring Diagram

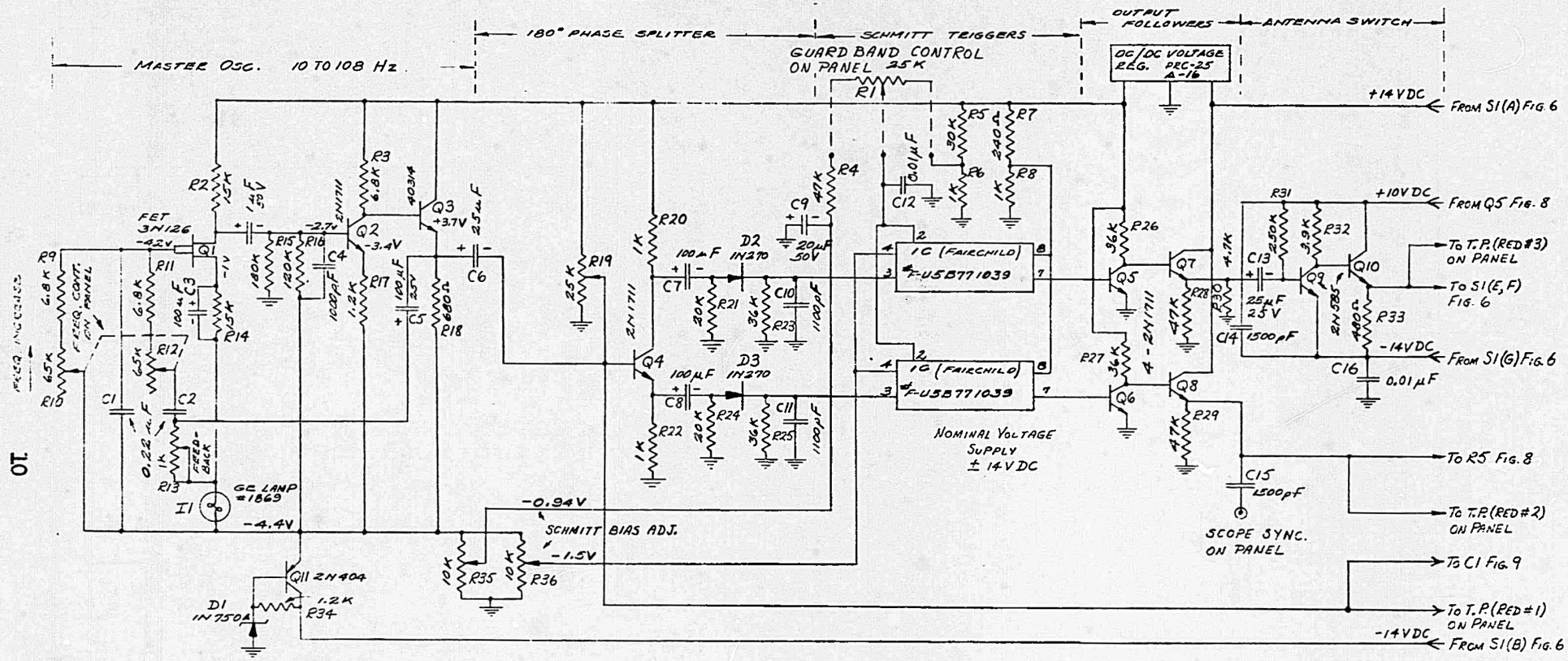

Figure 7. Master-Oscillator (Board No. 1), Schematic Diagram

An FET (Q1) rather than a bipolar transistor is used in the first stage, in order to present near-infinite resistance to the frequency-determining elements, thus avoiding an unstable parameter: Input resistance. The frequency-determining elements comprise the dual potentiometer (R10, R12) and two 0.22 uF capacitors (C1, C2). Frequency ranges from 10 - 100 Hz.

An emitter-follower (Q11) output circuit provides sufficient power to the lamp circuit, although very little power is required to drive the circuits following the oscillator. The lamp is operated at a filament temperature where the resistance changes quite rapidly with applied current. Thus, the amount of negative feedback (which is proportional to the AC voltage drop across the lamp) is automatically adjusted until a new balance is achieved. The actual level of the oscillator output is not critical as long as it is steady, and can be adjusted by a trimpot (R13), as shown in Fig. 7. A test point on the panel (RED #1) can be used to check oscillator output level and waveform.

The Antenna Switch and Retransmitter power are directly controlled by a squared-up version of the oscillator output. (The sine output is also used, as a reference in the tape-speed servo subsystem). Two Schmitt Triggers (Fairchild) are connected to a simple 180° phase splitter (Q3, Q4) in order to provide the two opposed squared outputs needed for the Antenna Switch Retransmitter control, and modulation to the Tape Deck control channel. Trigger outputs are isolated via individual amplifiers (Q5, Q6) and followers (Q7, Q8).

The duty cycle of the output waves is made variable (R1) so that a Guard Band can be created on each side of the transmit period. This can be considered as a safety margin at a small cost in transmitting time, and can be used to minimize transient effects occurring at the switching instants

and allow for the inevitable slight instability of voice energy phasing caused by mechanical instabilities influencing short-term tape speed.

Also shown in Fig. 7 is the driver circuit (Q9, Q10) for both the Antenna Switch and the Retransmitter power control. The circuit, a simple amplifier and power follower, is needed because greater voltage swing and power are required to drive the Antenna Switch than can be obtained readily from the trigger/follower circuits. This because diode turn-on current in excess of the RF peak must be supplied when the Repeater is operating in the Retransmit mode, so as to prevent opening the Antenna Switch during the RF cycle.

3.1.2 Modulator/Demodulator (See Fig. 8)

Difficulties were encountered in passing the master-oscillator frequency through the Tape Deck for servo control. Most important, phase shift at low frequencies was caused by the magnetic heads. The trouble was narrowed down to the heads by attempts to improve all relevant low-frequency RC couplings, in the hope of reducing the shift sufficiently. It was also thought that frequencies down to 10 Hz could be sent through the Tape Deck at reduced level, thus establishing servo control. However, this did not prove feasible, and a simple carrier system was built as a solution to the problems.

At $7\frac{1}{2}$ ips tape speed, and using the highest practical carrier frequency (6 kHz) modulated by square waves from the Schmitt Trigger a very satisfactory phase-shift-free tone-burst sequence resulted. 6 kHz was selected because it was the highest that could be passed through the Tape Deck at a high level (for lowest background noise), bearing in mind that tape speed is subject to large variations as part of its basic function.

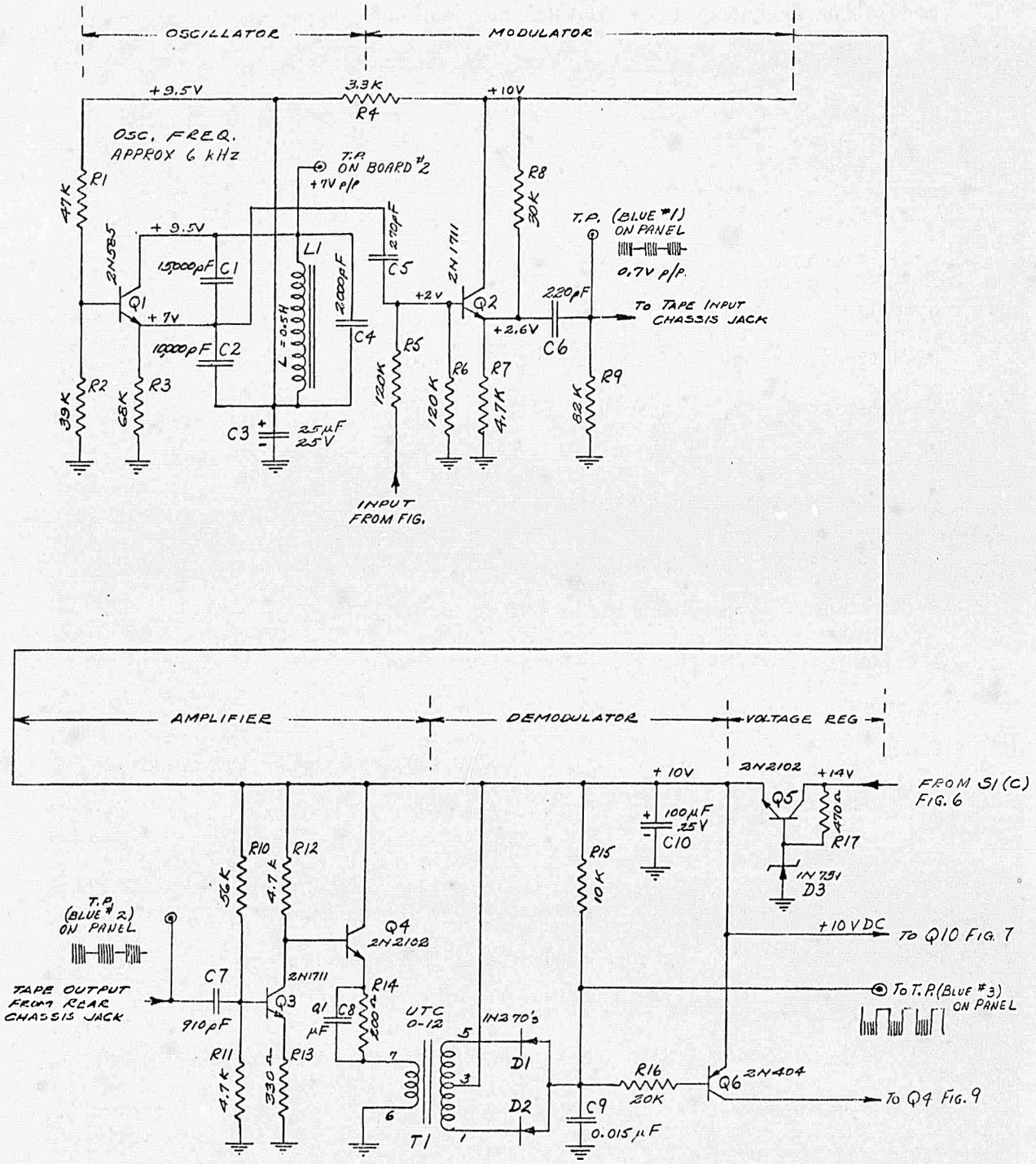

Figure 8. Tape-Deck Control-Channel Modulator/Demodulator (Board No. 2), Schematic Diagram

The higher the carrier frequency, the more precisely can the original modulating frequency (10 - 100 Hz) be recovered, since the filtering requirements are reduced accordingly. This is quite important if an equipment accuracy comensurate with short-term tape-speed instabilities is to be achieved.

The modulator circuit (Q2) is effectively a switch or gate which releases bursts of 6-kHz energy synchronously with the master oscillator's (Q1) positive half cycles. The low-frequency (DC) component resulting from the switching action is almost entirely removed by successive RC undercouplings, such that only clean tone bursts, with nothing between the bursts, are recorded.

The demodulator is severely RC undercoupled into a single amplifier stage (Q6) with a gain of about 15, so as to remove the remaining low-frequency components plus any that accumulate within the Tape Deck electronics for any reason, including the rectification of remanent RF energy from the Retransmitter. A direct-coupled emitter follower (Q4) feeds a push-pull peak rectifier (T1, D1, D2), thus recovering the original modulating waveform envelope except for some residual carrier. It was possible to reproduce the original phase extremely closely, partly because it was a square wave, where zero crossings are most important. The recovered wave drives a pnp transistor (Q6), which is really part of the phase-comparator or combining circuit (Fig. 9). The phase-comparator output eventually automatically regulates the tape speed, so that the comparator output is the DC equivalent to a one-quarter-duty-cycle pulse train.

3.1.3 Quadrature (90° Lag) Circuit (See Fig. 9)

For the tape-speed servo to control the motor equally well in either direction from a center speed or frequency, it is necessary to furnish

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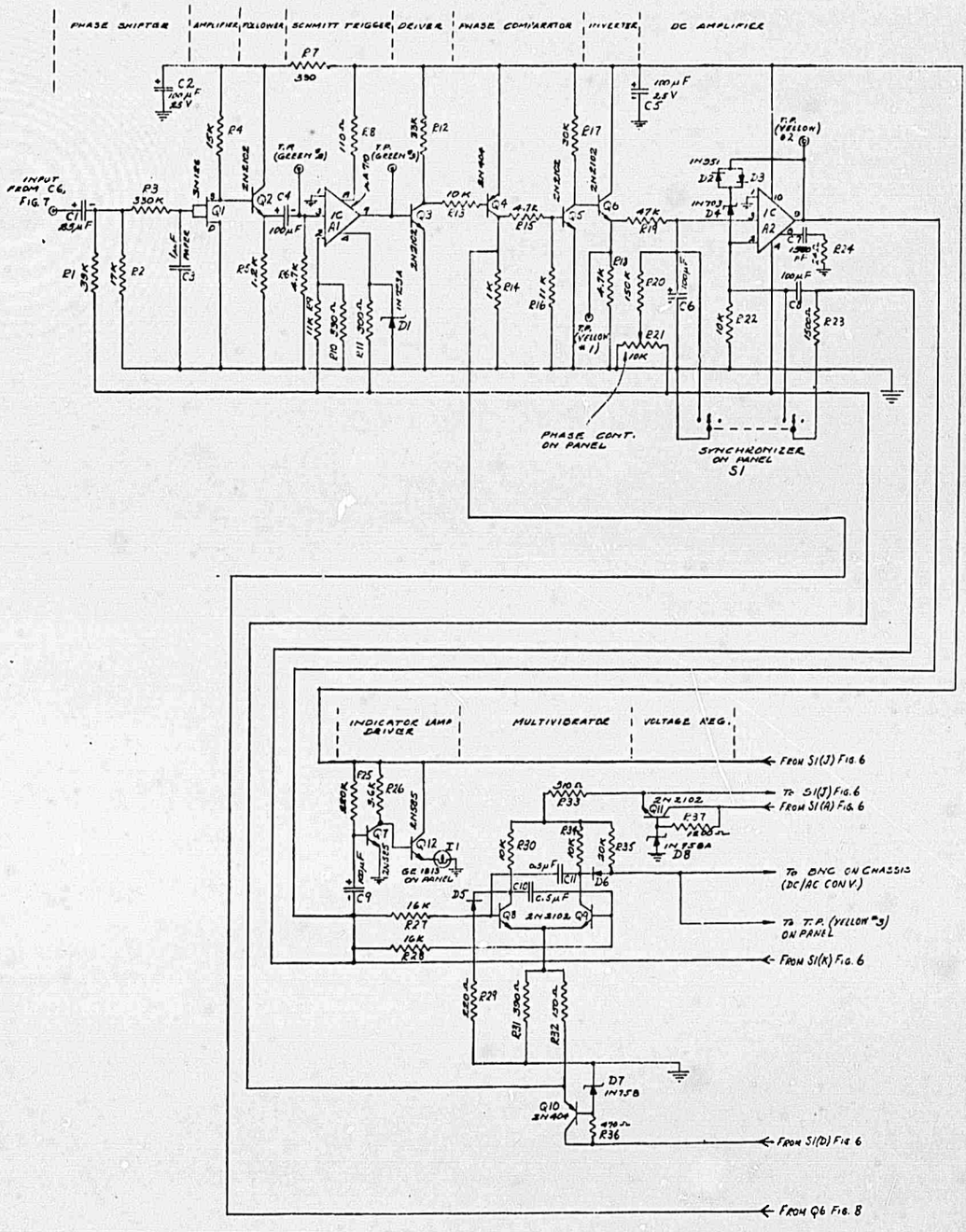

Figure 9. Tape-Deck Delay Servo System (Board No. 3), Schematic Diagram

the phase comparator with a second input, in addition to the one via the Tape Deck. This second input must be at 90° lag (or 270°) to the original master oscillator frequency. When the two square waves 90° apart (actually, 270°) are combined, the result is a train of one-quarter-duty-cycle waves. This is the nominal or center condition, as the comparator output can vary during search for lock from zero duty cycle to one-half duty cycle, according to the shift of the tape-delayed wave.

A simple circuit consisting of a resistor (R3) feeding into a capacitor (C3) was chosen, since this greatly reduces any harmonics present at the input. The alternate would be to provide a shift of 90° lead, which would greatly increase harmonic content. Although harmonic content is small in any case, the difference between the two schemes is quite marked when setting up an accurate time delay, as was the intent here. A distorted wave crosses zero at displaced points and, thus, any attempt to construct a valid square wave is difficult, since wave symmetry is lost.

The lag results in severe voltage loss if accuracy of the 90° shift is to be attained. In the actual case, some 46 dB voltage loss is suffered at 100 Hz master oscillator rate, and 26 dB at 10 Hz. However, the average phase error is about 1-1/2 degrees from zero, and even this can be partly cleaned up elsewhere. Capacitor loss was checked; it contributed little to the error.

An FET amplifier stage (Q1) provides both the high input resistance necessary for phase accuracy and a voltage gain of about 15. The resulting output level is enough to drive the following Schmitt Trigger (A1) used as a squaring device. An isolating follower (Q2) is used between

amplifier and trigger because of the trigger's low input resistance. The trigger output feeds the reference leg of the phase comparator (Q4) through an intermediate driver (Q3).

3.1.4 Phase Comparator (See Fig. 9)

The phase comparator (Q4) is the heart of the servo system; it compares the phase of the Tape-Deck-delayed wave from (Q6, Fig. 8) with that of the 90°-shifted wave. Its output is RC averaged (R19 and C6, Fig. 9) and amplified (A2) and used to control the frequency of an oscillator (multivibrator, Q8, Q9). The oscillator, in turn, determines the tape speed and, thus, the delay applied to the Tape-Deck inputs, and the Tape-Deck outputs feeding back to the comparator.

The main function is performed by coupling the outputs of two electronic switches (Q6, Fig. 8; and Q4, Fig. 9) to a single resistor (R14, Fig. 9). Each switch applies the same voltage, resulting in an output of positive pulses with varying duty cycle. When the tape-caused delay is exactly 180° (half a chopping cycle), a three-quarter-duty-cycle wave results. This is reversed to become a one-quarter-duty cycle, which is then averaged and amplified as DC(A2). This DC equivalent to the one-quarter duty cycle is balanced out with negative bias applied to amplifier A2; in effect, then, the phase comparator output is zero. Any variations from this zero condition would be due to servo errors (about $\pm 2^{\circ}$), and it is these variations (error voltages) that are amplified, as positive or negative control voltages for the multivibrator.

The bias applied to A2 to balance out the phase comparator output is adjustable by means of a front-panel control (R21, Fig. 9 and 9, Fig. 5). This control, once set, seldom requires readjustment, so long as accumulated servo errors remain fixed in terms of angles.

The amplifier (A2) provides an effective voltage gain of about 300; its basic gain of 1000 is reduced due to its own input resistance. This gain is sufficient to provide stiff servo control without any evidence of hunting. Three diodes (D2, D3, D4) are used in a feedback path between amplifier output and inverting input. Thus, any excess error output (plus or minus) beyond certain fixed levels will, due to the increase in negative feedback, produce a sharp loss of gain. This prevents the amplifier from feeding excessive voltage swings to the multivibrator which, in turn, would cause excessive output-frequency variations. Too low a frequency is unacceptable to the DC-to-AC converter; too high is unacceptable to the Tape-Deck motor. The circuit has no effect on the high system gain at the normal output levels.

The Tape-Deck motor can be locked up at any master-oscillator (chopping) frequency in the range 10 - 100 Hz. The lower chopping frequencies (10 - 20 Hz) can strain the servo error to operating points near either of the extremes (55 or 100 Hz) permitted by the diode limiting. The higher chopping frequencies, on the other hand, can cause motor lockup at several speeds, because of the larger number of chopping-frequency periods recorded on the length of tape between record and reproduce heads. The actual number of stored periods, or "waves", is unimportant, so long as lockup occurs when an extra half a wave is present. For example, there is practically no difference between 25-1/2 or 27-1/2 waves in storage; the delay time of either extra half-wave is the important factor.

The preference is for lockup to occur when servo-system error is a minimum, i.e., nearest to zero control voltage input to the multivibrator. For this reason a switch is provided to momentarily force the

control voltage to zero, so that the servo will lock up automatically at the nearest valid condition (half-wave) to zero. Depressing the SYNCHRONIZER Switch (S1, Fig. 9 and 10, Fig. 5) momentarily sets up the zero-control-voltage (center-frequency) condition; on its release, the instantaneous error voltage determines the direction of control.

The multivibrator, a conventional VFO, is preset for a center frequency of 75 Hz at zero control voltage. Sensitivity is, roughly, 10 Hz/V. A positive error swing increases the output frequency, and vice versa. The range is limited to 55 - 100 Hz, as explained previously.

3.1.5 Servo Stability Indicator (See Fig. 9.)

The STABILITY Indicator Lamp (8, Fig. 5, and I1, Fig. 9) is connected to a lamp driver circuit (Q7, Q12) fed by the phase-comparator output amplifier (A2).

The circuit comprises a long-time-constant (22 seconds) RC coupling (C9, R25) to an amplifier (Q7) and follower (Q12). The lamp itself is connected in the emitter circuit of Q12. During normal operation (zero control voltage) the bias on Q12 is such that I1 glows with a dull light. However, when the DC control voltage to the multivibrator is varying, the changing bias causes I1 to either cutoff or glow brightly. This occurs during periods of servo search; when lockup occurs, the lamp intensity returns to normal (dull).

The STABILITY Indicator, although very convenient, is not infallible as to servo lockup. To ensure that lockup has really taken place, a voltmeter must be connected to Yellow Test Point (T.P.) No. 2 (13, Fig. 5) to verify that the voltage present is steady within $\pm 3/4$ volt of zero. (If not, the SYNCHRONIZER Switch must be depressed to restart the search.) In actual practice however, with the Tape Deck operating properly, the STABILITY Indicator never failed to indicate lock.

3.1.6 Test Points (See Figs. 5 and 6.)

3.1.6.1 Colored Test Points

Five groups of Colored Test Points (T.P.), each comprising three T.P., are mounted on the control Panel. They are connected as follows:

a. Red

#1 - Master Sine Wave Oscillator Output

#2 - One of the Squared-Up Sine Waves (Includes Guard Band Action)

#3 - Driver Output for Antenna Switch and Retransmitter Control

b. White

#1 - Receiver Audio Output (Same as Red Voice Input Connector to Tape Deck)

#2 - Tape-Deck Voice-Channel Output. Ideal for Delay Check.

#3 - Not Connected.

c. Blue

#1 - Modulated Carrier Input to Tape Deck Control Channel.

#2 - Tape-Deck Control-Channel Output. Also good for Delay Check.

#3 - Recovered and Delayed Control Square Wave.

d. Green

#1 - Not Connected.

#2 - 90^{o} - Lag Sine Wave

#3 - Squared Version of 90^{o} - Lag Sine Wave

e. Yellow

#1 - Variable-Duty-Cycle Pulses in Phase Comparator

#2 - Comparator Amplifier Output (Servo Error Signal)

#3 - Multivibrator Output (Input to DC-to-AC Converter)

3.1.6.2 Battery-Voltage T.P.

All four dry batteries are grounded at one end, with their "hot" sides going through individual fuses to terminals (NEG. 15 V, POS. 15 V) on the Control Panel. These terminals serve both as voltage output and check. No voltage T.P. are provided for the regulated supplies.

3.1.6.3 Details of Colored T.P.

a. Red

#1 - Level should be about 1-1/2 V on AC Meter (4 V p-p on scope). Several seconds are needed for automatic regulator to settle down, after a disturbance, such as frequency change. Very steady indication during normal operation, with a very "clean" wave. Level is adjustable by means of black trimpot Feedback Control on Board No. 1 (R13, Fig. 7).

#2 - Output influenced by GUARD BAND Control (check, to verify). Some contamination of wave is harmless, as long as edges are sharp. Level can range from 0 to +10 V (4 V on AC Meter). Momentary (up to 10 seconds) grounding is harmless.

#3 - With Antenna Switch and Retransmitter control circuits disconnected, level ranges from +13 to -13 V (11 V on AC Meter). Reconnecting control circuits changes level from +7 to -6 V. GUARD BAND Control can affect duty cycle of square wave. Momentary (up to 10 seconds) grounding is harmless.

b. White

#1 - Can use this output as that of a chopped Receiver, with MODE Switch in REPEATER Position and Retransmitter off. Audio received from an originating transmitter can be seen clearly on scope, alternating with Receiver noise. This is useful in checking Antenna Switch operation, since Receiver input is thus chopped. Can also be used in forming a basic interrupted-speech link, if the signal is not so strong that is will leak through the Antenna Switch when it is off. The connector can be grounded without harm.

#2 - Output suitable for use with VU Meter as monitor for speech level fed to Retransmitter in REPEATER mode. Also ideal for comparing output on chopped scope, of White #1 as check on phasing of audio (correct delay). Connector can be grounded without harm.

c. Blue

#1 - Output should be clean burts of 6-kHz tone, with approximately sine waveshape (not critical). Burst level should be about 1 V p-p. Can be grounded.

#2 - Output similar to Blue #1, with amplitude dependent on Tape Deck gain setting. Any indication on Tape Deck Meter is good; typical is 2 V p-p (0.4 V on AC Meter). Can also be used with chopped scope to check servo action and delay phasing by comparison with Blue #1 output. Can also be substituted for White T.P. for fundamental check (voice). Has the advantage here of not needing any transmission or signal-generator input to Receiver. Both Tape Deck channels are sufficiently alike to validate this check method. Can be grounded.

#3 - Output is a sharp-edged square wave, with some rounding at top and unfiltered carrier at bottom. As, roughly, the middle portion if the wave is effective, distortions are harmless and better not removed. Removal would only introduce phase shift, hence reduce servo accuracy. Typical level is about 2 V p-p centered at 8 V DC above ground. Can be grounded.

d. Green

#2 - Output level should be about 1.5 V p-p (0.5 V on AC Meter) and very clean at 10 Hz. Level is inversely proportional to frequency. Can ground.

#3 - Level should range from -0.5 to +0.5 V, square (0.8 V on AC Meter), at all frequencies. Momentary ground is harmless.

e. Yellow

#1 - Gives best indication on scope of servo action; range of 0 -8 V is normal. Minor effects on action, such as tape-speed "wow", and any other servo-loop disturbances, are seen clearly as duty cycle changes. DC voltmeter can be used instead of scope, as servo settles at about 2 V average, and voltage changes directly represent duty-cycle changes. Can be grounded.

#2 - Servo-error signal can be monitored on zero-center DC Voltmeter. Meter can also be used to verify action of SYNCHRONIZER Switch and STABILITY Indicator. Maximum levels range from +4 V to -1-1/2 V. Momentary ground is harmless.

#3 - Output is a squarish wave, but is still suitable for exciting DC-to-AC Converter. Level should be about 5 V p-p (about -4 V DC average). Do not ground when DC-to-AC Converter is on.

3.2 POWER SUPPLY (SEE FIG. 6.)

The drains from the four BA-386 batteries vary with battery age and actual Repeater settings at the time of measurement. However, the following chart is a fair indication of the drains in the four possible modes

DRAIN IN mA

BATTERY	REC.	REXMIT	STDBY	REPEAT.
+ No. 1	40	40	40	100
+ No. 2	20	0	0	80
- No. 1	20	40	20	50
- No. 2	40	40	40	40

Drains from the AN/PRC-25 internal batteries are almost normal. The Receiver draws normal power, depending upon the way it's used. The Retransmitter draws full power when the MODE Switch is in TRANSMIT position. When the MODE Switch is in REPEATER position, the drain from the 14 V section is about half of normal, but the filament drain is normal. Thus, battery life may possibly be determined by the filament cells.

Power-supply decoupling is an important problem, especially as the low switching rate of 10 Hz must be accommodated, and cross feeds can cause undesirable phase shifts, false Schmitt Triggering, etc. Satisfactory conventional RC decoupling circuits would be troublesome, i.e., they require very-low series-resistor values to maintain reasonable voltage stability, and very-large capacitors, to be effective at 10 Hz. To overcome this, simple voltage regulators, consisting in each case of a transistor, zener, and resistor (e.g., Q10, D7, R36, Fig. 9), have been inserted into many of the power-feed circuits. Circuit voltages under this arrangement hold steady

within 0.1 V or so; and the source impedance presented is extremely low, a few ohms at most.

3.3 DC-TO-AC CONVERTER (SEE FIG. 10.)

This unit furnishes the power for the Tape-Deck electronic and motor circuits. The output frequency (50 - 100 Hz) of its 117 V AC supply is dictated by the servo system. Variations in the supply frequency from the nominal 60-Hz requirements of the Tape Deck seem to have no effect on the electronic circuits.

The Converter is a Terado Model 50-201, designed to operate from a 12 V storage (automobile) battery. Its normal output frequency is at or near 60 Hz. As made by Terado, a mechanical vibrator determines the output frequency, and a transistor-switch arrangement (Q3-Q4) pulses the transformer (T4) to provide the desired AC output. The unit has been modified, however, so that an external signal can be used instead of the vibrator (not shown in Fig. 10), whose frequency is fixed by mechanical parameters. The external signal, which comes from the multivibrator of Fig. 9, is fed into a circuit (Q1) which, in turn, activates the same circuits as did the vibrator. Thus, the output frequency is dependent upon the frequency of the multivibrator. Note that the transistor-switch arrangement could be destroyed if an abnormally-low (below 50 Hz) vibrator excitation frequency were used, because of the consequent high magnetizing current. The modification has been designed to prevent this occurrence.

Current drain from the 12 V Battery by the Converter is about 4A. Thus, a fully-charged automobile battery might be expected to provide about two days (16 work hours) of practical service. As for the voltage charge on the battery, a drop down to 10 V will still permit proper Tape-Deck operation.

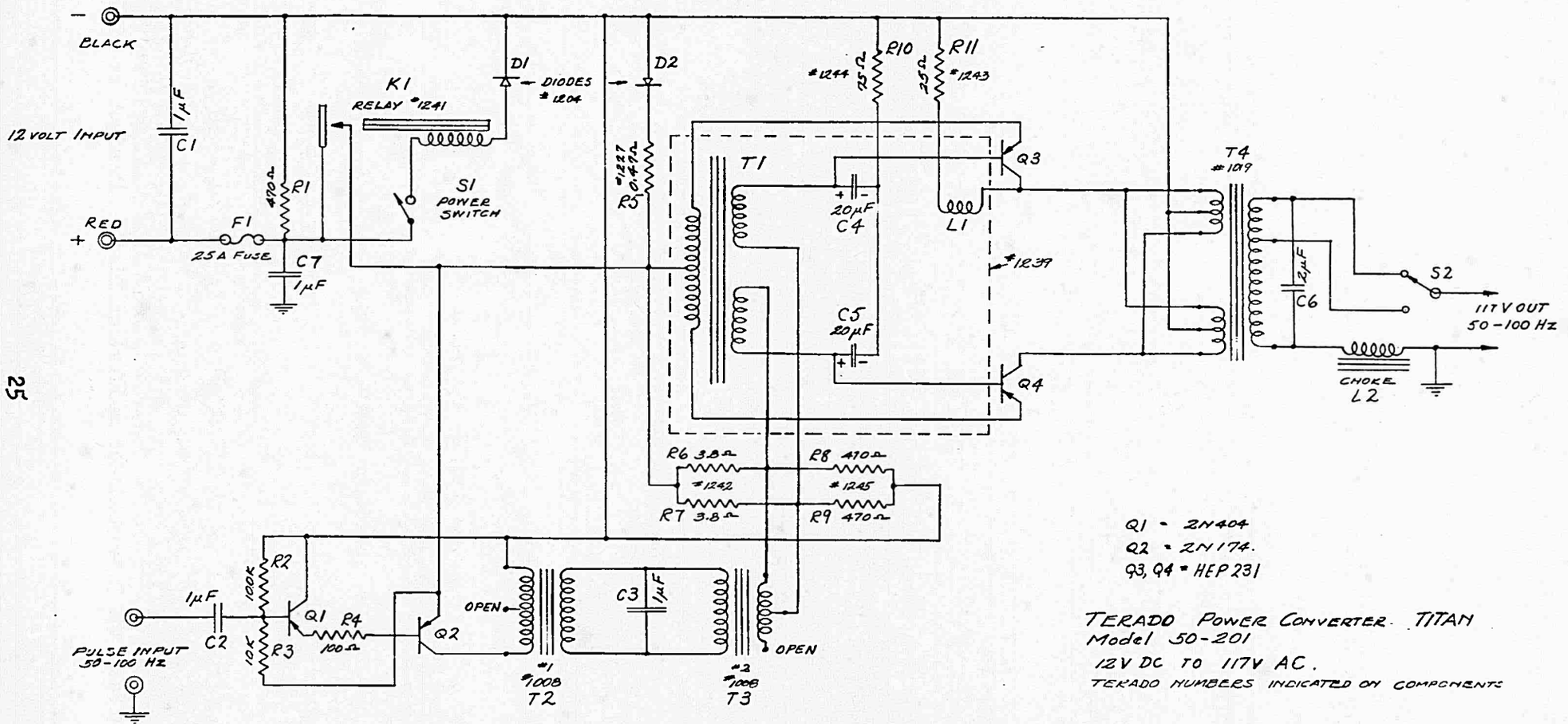

Figure 10. DC-to-AC Converter, Schematic Diagram

A strong magnetic field surrounds the Converter while it is operating. To avoid disturbing the Repeater circuits through undesired coupling, the Converter should be located at least three (3) feet away from the Repeater.

3.4 TAPE DECK

This unit is a Sony Model TC-350 Stereo Record and Playback. Record and playback electronics are separate, thus enabling almost simultaneous record and playback. The slight delay is due to the 1-1/2 in. separation between the record and playback heads and the tape speed itself.

The only modifications made to the unit were to ground the input and output connectors to the frame at a point behind the rear panel. This was done to reduce the effect of rectification of RF signals within the Tape Deck when the Retransmitter is operating. Such pickup can easily add a substantial DC component to the output; the result can be troublesome in the servo system, but will have little effect on the voice channel.

Excessively-low-frequency input to the Tape Deck causes a high current drain on the DC-to-AC Converter Battery due to the disproportional increase in magnetizing current. This has been compensated in the servo system, as described previously.

At unduly-high frequencies the Tape-Deck motor will not follow, and becomes unstable. Suitable limiting has alleviated this problem, but another remains. Since tape speed is always subject to an appreciable range, the Tape-Deck audio-output level is also subject to variations. These variations are directly proportional to speed; hence, the higher the speed the higher the output level. The effect of higher audio-output level on the servo system can usually be neglected; the only problem would be too-low a level. For the voice channel, the situation is different. The higher output voltage can affect the Retransmitter modulation level. It might be argued that the

AGC/overload characteristic of the Retransmitter's microphone amplifier, through which the Tape-Deck output passes, would alleviate the problem. To some extent this is true; however, the microphone amplifier limits rather than adjusts the gain. Limiting, with its attendant distortion plus the accumulation of inherent undesired tones, harmonics, cross-modulation products, etc., only further degrades an already degraded speech quality. Thus, some way must be found to avert the problem.

The existing solution is to recalibrate the audio-transmit level each time the servo system (and tape speed) has been disturbed (by, say, changing the chopping rate). Ideally, this could be done by transmitting a standard-deviation tone from a separate remote transmitter, or from a signal generator. For field operation, this is not too practical a solution. An alternative approach would be to use as an arbitrary reference the 150-Hz squelch tone that is always transmitted by the originating AN/PRC-25 Transmitter. A third approach would be to use voice for setting the level; but, even using the Tape-Deck's output meter, this method is subject to some inaccuracy. The choice, then, depends upon what is most practicable at the time.

A further difficulty in setting up standard audio-output levels is posed by the Receiver itself. When the Receiver Volume Control is set to maximum, which would seem to be a nice, fixed level setting, the Receiver itself distorts its own output. For example, three Receivers were checked; all three showed significant distortion with a 10-kHz-deviation tone input, and worse with voice input. Thus, to avoid distortion, the Volume Control cannot be set to more than 80% of maximum. Although the loss in gain is easily offset by the inherent gain of the Tape Deck amplifier, the level setting cannot be considered as "calibrated".

To avoid as much distortion as possible, the Connectors at the rear of the Tape Deck were used. They are sufficiently sensitive to permit connection to the 6-kHz-tone and voice sources. Thus, the use of the Tape-Deck Microphone Amplifier (front-panel connectors) was avoided, cutting down on sources of distortion.

The Tape-Deck LINE OUT level is very high as compared to the needs of the voice input to the Retransmitter. Hence, a simple resistive divider (R1, R2, Fig. 6) terminating in 560 ohms, was used as the coupling circuit. Since this doesn't load the Retransmitter input, a monitoring handset can be used in parallel, with negligible input degradation. The Receiver is also virtually unloaded by the Tape Deck.

As far as tape requirements, choice of tape is not too important. The Control Channel is almost immune to tape noise, dropouts, etc., and the voice requirements are not that demanding.

3.5 ANTENNA SWITCH (SEE FIG. 11.)

The Antenna Switch is, effectively, two switches operating from the same control wave but in opposition to each other. In essence, then, the Antenna Switch is the equivalent of a single-pole, double-throw relay or switch.

PIN diodes (D1-D4) have been used throughout and, together with their driving circuits, somewhat load both the Receiver and Transmitter. Thus, received signals are attenuated, as is retransmission power to the Antenna. The exact loss depends on the operating frequency, largely because of antenna-impedance variation with frequency. In any case, attenuation is a matter of only a few dB, and does not detract from the validity of the tests made to establish system feasibility. It merely reduces the Repeater's effective gain in terms of distance gained between terminals for a given voice-output standard.

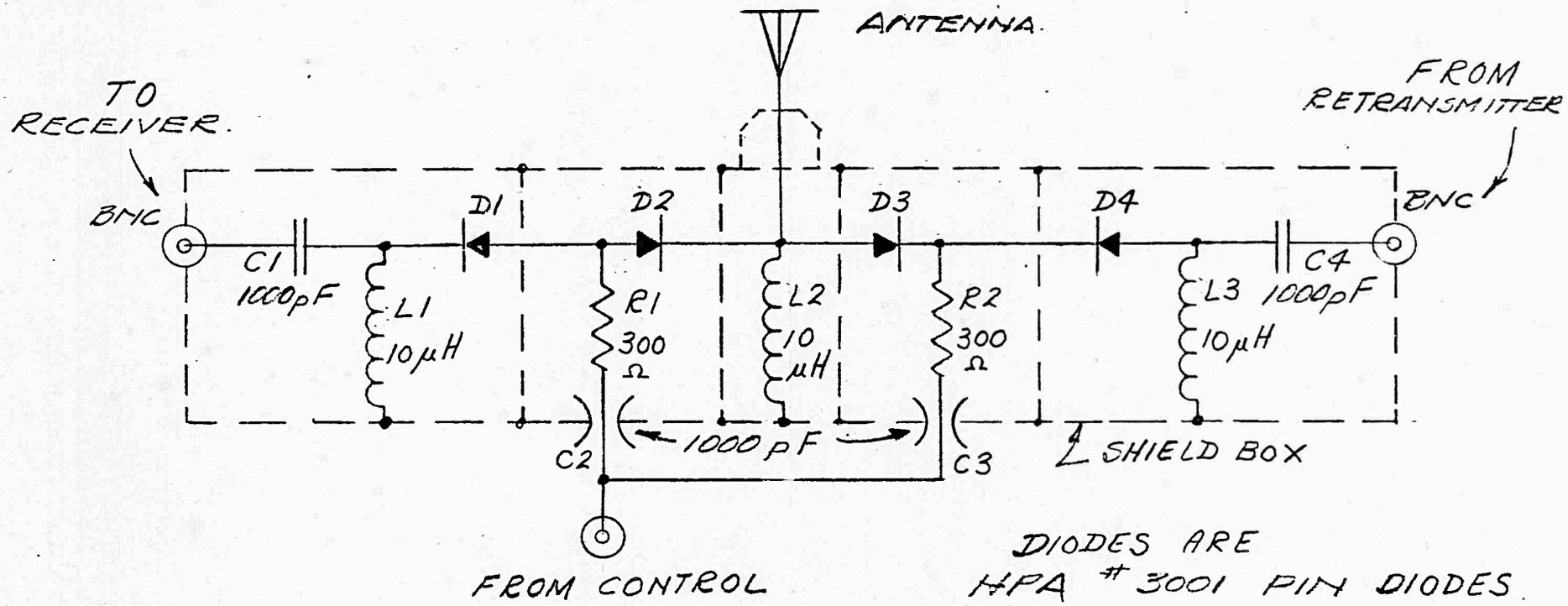

Figure 11. Antenna Switch, Schematic Diagram

Switch action is almost instantaneous, and is closely synchronous with the zero crossings of the master oscillator waveform. Control power is derived from the driver shown in Fig. 7.

3.6 RECEIVER

This unit is an AN/PRC-25 unmodified except for removal of its antenna mounting block. This was done to avoid local radiation in the vicinity of the Repeater and reduce the effects of operator body movements.

3.7 RETRANSMITTER

This unit is also an AN/PRC-25, with its antenna mounting block removed. A further modification was made by removing the Squelch Tone Generator Module (A23). This prevents transmission of the 150-Hz squelch tone, which would have loaded the voice circuit unnecessarily. Squelch operation is still maintained by the originating Transmitter. The latter transmits the 150-Hz tone, along with any existing voice signal, which "unlocks" the Remote Receiver.

A further modification to the Retransmitter was the addition of a system of three synchronized switches (Choppers Nos. 1, 2, and 3, Fig. 12). These circuits are located in compartment added to the rear of the Retransmitter (Fig. 3).

The switches interrupt (chop) the Retransmitter B+ and bias circuits, and are driven from the same control line that drives the Antenna Switch. With the switches open there is virtually no RF leakage, although the AN/PRC-25 synthesizer is deliberately left operating because of its long settling time. With the switches closed, there is a slight power loss from that of a normal AN/PRC-25; this is due to a voltage drop across the controlling circuits. This power loss is insignificant as far as feasibility of single-frequency repeating is concerned. Also, the power loss could be made up through modification, although this, in turn, would require modification of other circuits.

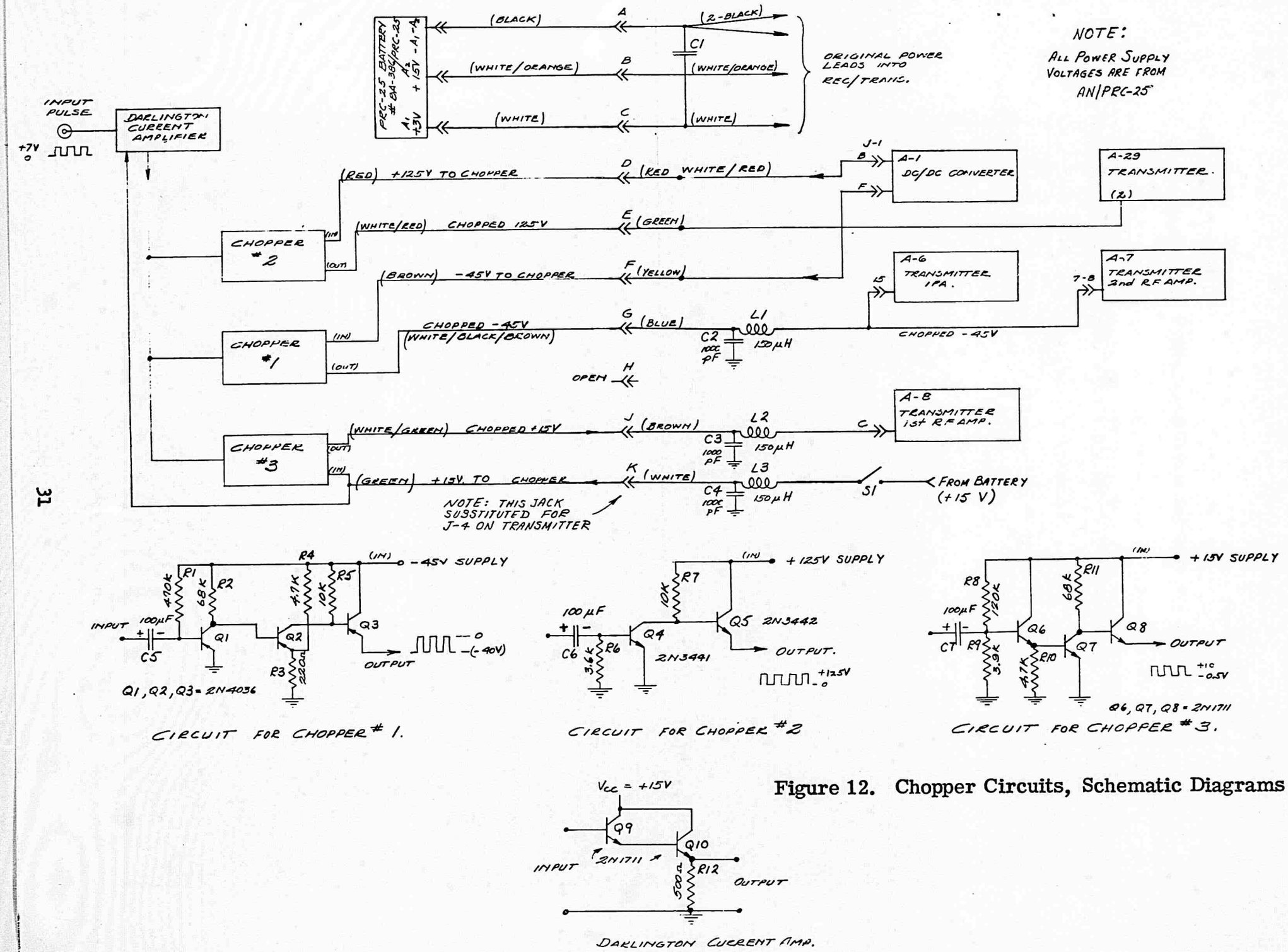

Figure 12. Chopper Circuits, Schematic Diagrams

Although the switches are AC coupled for convenience and simplicity, they remain "on" even when control is removed. This feature enables setting up full-time transmission between Retransmitter and Remote Receiver for adjustment or noise-measuring purposes.

3.8 CROSS COUPLING (SEE FIG. 6.)

For the most part the voltage levels of the different circuits are comparable, and the impedances are, generally, quite low. As a result, very little shielding of wires and circuits was done, nor have any effects been observed due to undesired cross couplings.

4. INSTALLATION AND OPERATION

4.1 INSTALLATION

Interconnection of units is accomplished with Fig. 6 as a guide. The cables provided with the unit are long enough for operation with the Control unit removed from the main Repeater Cabinet.

Locate DC-to-AC Converter at least three (3) feet away from Repeater Cabinet and from Tape Deck.

Although it is not essential, locating the Repeater Cabinet and Tape Deck on a metal-covered surface is advantageous. Such installation lessens the effects of operator body capacity.

4.2 OPERATING INSTRUCTIONS

4.2.1 Required Items

The following items are required to perform voice repeating with no measurements (minimum Repeater function):

a. Main Assembly in Cabinet

b. Tape Deck

c. DC-to-AC Converter and 12 V, 50 A-hour Lead-Acid Storage Battery

d. Set of Cables

e. Antenna and Antenna Switch

f. Set of four (4) BA-386 Batteries, plus Spares

If controlled tests are to be performed, the following additional items are required:

a. Audio Oscillator (Calibration Not Required)

b. FM Signal Generator with Metered Frequency Deviation

c. AC Meter or VU Meter

The following items would be useful, but are not for performance testing purposes.

a. Oscilloscope, DC to 10 kHz minimum, Dual-Trace or Switched. For field use, 117 V AC Supply (DC-to-AC Converter) cannot be used to power the scope, although a conventional automobile-type inverter can be connected to the 12 V Battery in parallel with the Converter. In such case, the scope must be free of RF radiation. The alternative is to use a scope with its own battery power.

b. Multimeter

c. Handset

d. Spare Fuses and Transistors

e. Jumper Leads

4.2.2 Operation as Field Single-Frequency Repeater (See Fig. 5.)

a. Connect Handset to Repeater Receiver.

b. Set MODE Switch (7, Fig. 5) to RECEIVE Position.

c. Set Receiver Power Switch to ON Position.

d. Operate Receiver as transceiver in two-way communication with one Remote Terminal, and verify that communication quality is close to that normally expected.

e. Repeat Step d. for remaining Remote Terminal. Individual links are now ready for use.

f. Request an attempt at direct two-way communication between both Remote Terminals, and obtain results of check. (Repeater can be left in RECEIVE Mode, to serve as a Command Center.) If Remote-Remote communication is possible, even if only in one direction and weak, it will cause an echo to appear at the receiving end. If two-way contact is established, need for the Repeater is gone. Hence, Remote Terminals must be moved farther apart, and Steps a. through f. repeated until need for Repeater is evident, and all systems are "go".

g. Request modulation from Remote Transmitter to start in, say, one (1) minute, to allow placing Repeater into normal operation.

h. Set MODE Switch to REPEATER Position.

i. Set Power Switch on Retransmitter to ON Position. (Handset can remain connected to Receiver, or be disconnected, at operator's option.)

j. Place Tape Deck in RECORD MODE, and set both Tape-Deck MODE Switches in TAPE Position.

k. Set Receiver VOLUME Control clockwise to below 3/4 maximum (at about 7th white marker).

l. Adjust Tape-Deck Left REC. VOL. Control for a center reading on Left VU Meter.

m. Adjust Tape-Deck Right REC. VOL. Control for Right VU Meter indication where Remote-Transmitter modulation will not make meter pointer deflect off-scale. Exact level is arbitrary, and can be reset during operation, since this is not a controlled test. Repeater should now be operating properly in end-to-end, two-way mode.

For the Remote Terminal to obtain "service" (instructions, etc.) from the Repeater, it is advisable that some other signal be used than voice, e.g., a fairly-long whistle. Repeated voice in the Handset is confusing, since it is combined in the Receiver with directly-received voice.

4.2.3 Laboratory Measurements under Controlled Conditions

The number of possible arrangements for making performance measurement is very large. To complicate matters, if the Remote Transmitter is an AN/PRC-25, it is a cause of considerable audio distortion, which is of uncertain magnitude due to both the test level and to mismatch with the RF of the Repeater Receiver. Thus, to obtain the most valid test results, use of an FM Signal Generator is recommended, at least for one of the links. The second link can terminate in an AN/PRC-25 which has been selected for proximity of its RF (within, say, 1 kHz) to that of the Retransmitter. Receiver distortion alone is small, compared to that produced in the Transmitters. Under this setup, conditions in both links might not be identical,

but will not invalidate the measurements.

Signal-Generator connection is by radiation, except for audio-standardization procedures. Audio-standardization (level to Retransmitter) is performed as follows:

a. Remove Red Plug from Red VOICE INPUT Connector (6, Fig. 5) on Control Panel, and connect AC Meter (or VU Meter) to the Red Plug just removed.

b. Set FM Signal Generator for 10-kHz deviation (or any other desired), with any medium-frequency tone (internal or external). Note reading on Right Tape-Deck VU Meter.

c. Remove Receiver Antenna Switch Cable from BNC ANT Connector, and connect Signal Generator instead.

d. Set MODE Switch to TRANSMIT Position and set Receiver Power Switch to ON Position.

e. Set Receiver VOLUME Control for 1 V reading on AC Meter (0 dB on VU Meter).

f. Disconnect Signal Generator and reconnect Receiver Antenna Switch Cable.

g. Connect Audio Oscillator to Red VOICE INPUT Connector on Control Panel.

h. Set Tape-Deck MODE Switches to SOURCE Position.

i. Set Retransmitter Power Switch to ON Position.

j. Turn on Audio Oscillator and adjust it and Tape-Deck Right REC. VOL. Control for same reading as in Step e., above. Note position of Right Tape-Deck VU Meter, as this corresponds to the deviation reference set up originally by the Signal Generator. If the reading is the same as that noted in Step b., above, then the Retransmitter's deviation will be the same as that of the Signal Generator (10 kHz). If the Receiver VOLUME Control setting is not touched, then a 10-kHz deviation test tone at the Remote Transmitter will be repeated by the Retransmitter with the same deviation; i.e., no deviation translation.

The foregoing is not necessarily the best operating condition: It only standardizes the audio levels.

There is one other convenient way in which to set up the audio levels: Use a different frequency for the Retransmission link. Here the

Repeater MODE Switch is set to TRANSMIT Position, the Tape-Deck MODE Switches are set to SOURCE Position, and the Repeater Receiver is connected directly to its own Antenna (i.e., cable removed from Antenna Switch). The result is conventional two-frequency Repeating. (Some experimenting with frequencies is necessary to avoid regeneration caused by spurious radiations from the Retransmitter).

Actual setup prior to a test run must also include a knowledge of existing signal-to-noise ratio (SNR) in each link. Measurements can be taken in the conventional way at the Receivers outputs. For measurements on the Remote-Transmitter-to-Repeater Link, the Repeater MODE Switch must be in the RECEIVE Position. On the remaining link, the MODE Switch is set to the TRANSMIT Position.

Measurements on the Remote-to-Repeater Line are made with added RF noise and the Receiver working with a strong audio signal. Here the AC Voltmeter (or VU Meter) is used to compare the audio-plus-noise readings with the noise-only readings. The meter is connected to the Red Receiver Plug, similarly to the audio-level setup procedure. Where S+N/N is low, conventional correction procedure is used.

On the Repeater-to-Remote Link, the AC or VU Meter is connected to the proper pins on the pertinent AUDIO Connector of the AN/PRC-25 Receiver.

5. TEST RESULTS

5.1 RCA LABORATORY SETUP

The Repeater, Storage Battery, Tape Deck and AC to DC converter were interconnected so that only the main unit and the Tape Deck were located on a metal-covered table near the center of a large laboratory. The metal covering was purely for convenience in reducing body-capacity effects; it does not affect performance.

The Remote Transmitter (No. 1) Terminal was placed inside a small shielded cage, with an attenuator connected to its BNC ANT Connector and a wire to the microphone input on the set. The attenuator output was cabled via the cage wall to a short antenna located about four (4) feet from the Repeater Antenna.

Modulation was applied to the No. 1 Terminal from an Audio Oscillator (for calibration), Handset, or Word Test-Tape Recordings, as required.

The No. 2 Terminal (Remote Receiver) was located in a large shielded walk-in cage, out of earshot of the Repeater location. The BNC ANT Connector was connected within the cage to an attenuator whose output was cabled to a small antenna also a few feet from the Repeater. All antennas were roughly in a line, and about one half of the path loss was in the air path, moderately-strong signals were received at each Receiver.

A word here about frequency selection (RF) for test purposes. There is nothing basically, that prevents the use of any one of the AN/PRC-25 channels for the Single-Frequency Repeater. However, in practice there are two factors which indicate a preference toward certain frequencies. One is the matter of making the most advantageous match with the Repeater Antenna. This is significant because the normal matching network of the AN/PRC-25 is ineffective because of the way in which the Antenna Switch has been connected. For practical Repeater design it was connected to the 50-ohm ANT Connectors on the Repeater. Hence, it would be a poor match for any antenna at all frequencies and, in addition, the resistance of the Switch causes some impedance modification.

Using a crude measurement it seemed that about 48 MHz was the frequency at which the most power was radiated with the short antenna. For many tests though, maximum radiated power is unimportant, and any frequency will

satisfy.

The second factor influencing frequency choice is due to the frequency variation of different sets. Of the three AN/PRC-25s available for check, two of them were roughly 5 kHz mistuned from nominal, and approximately a working pair; the third set was about 3 kHz variance from the first two. This can be due only to inaccuracy within the crystal oscillator; thus it is expectable that it is a percentage error applicable to all frequencies. The foregoing is true in relation to a carrier at 30.30 MHz; however, it is plain that deviations from center frequency would be even greater at higher operating frequencies, and the differences likewise. So, in the interests of minimizing the crystal-oscillator effect on final frequency, it is advisable to select the lowest possible carrier value. Most of the testing done was at 30.30 MHz.

One other small contributor to a frequency-selection decision is the fact that a howl is present in the AN/PRC-25 at certain settings, possibly due to the synthesizer leaking energy into circuits and causing a heterodyne beat to occur. These are easily rejected as possible operating frequencies.

Controlled tests were not run, although the setup was suitable for introducing known amounts of noise into each link, measuring SNR for various conditions, and analysing all distortions present at different stages along the circuit. The following informal tests were run, and the comments following each give some idea of the general performance of the Repeater System.

5.2 TESTS

5.2.1 Sine-Wave Modulation

Sine-wave modulation at 1 kHz was applied to the No. 1 Terminal Transmitter such that 10-kHz deviation resulted (the reference standard).

The output of the Repeater Receiver (operating in the conventional mode) was examined for harmonic distortion; it contained from 10-20% second harmonic, plus other contaminants. This condition was found to depend on the actual AN/PRC-25 being used as the Remote Transmitter, for two reasons. The first was inconsistency in the limiting points of the respective microphone amplifiers (TX and RX). The second was the variation in radiated frequency with respect to the Repeater Receiver: A difference of 2 kHz was very detrimental. Such distortion is unavoidable in practice, and not significant in the usual AN/PRC-25 usage. However, when the latter is used in the Repeater mode, the distortion not only accumulates, but gives rise to further compounding because of cross modulation encountered in the circuits. Similar effects also occur in the Retransmit mode, and the results are comulative with the distortion in the first (originating) link.

5.2.2 Optimum Audio Levels

Tests were conducted for optimum audio operating levels. Test tones can be calibrated for 10-kHz deviation with no difficulty; said calibration was done as a reference. Experiments were also made for recoverability using other deviations, and it appears that little can be gained from forcing any greater deviation. In general, then, it seems that 8-10 kHz deviation is probably the optimum test-tone region.

As for voice, the originating Transmitter is normally under very weak control, since the talker's voice must be accepted over a wide range of levels, and the built-in microphone-amplifier limiting arrangement cannot be interfered with. As a result, voice performance is more difficult to assess. However, it does appear that severe overmodulation offers greater voice intelligibility over the whole system. In other words, overmodulation

seems to offset the Receiver noise heard during non-Retransmitting noise. The foregoing applies to original voice. On Retransmit, there is no apparent advantage from the use of high overmodulation. No sound explanation is yet available for this phenomenon. The best overall results were obtained when the voice bursts were centered around the 10-kHz-deviation region (with some slight overmodulation). Extensive additional tests are still required to determine the best audio levels with reference to type of talker, and with noise on the individual links.

Attempts were made to meter the audio input (from the Repeater Receiver) to the Retransmitter during Repeater operation. The results were useless. First, the audio was interrupted by the Receiver chopping pulses, and second, the strong Retransmitter output leaked back into the Receiver due to their proximity. Readings thus taken can be used only as reference points, and the true Retransmitter audio-output level can be determined only by operating the second link conventionally with prerecorded voice or tone instead of received audio.

5.2.3 Output Distortion

Tests for output distortion were conducted using a test tone. The test instrument was a 10-Hz-bandwidth selective voltmeter. The results indicated significant amounts of many undesired frequencies. Among the stronger ones detected were the second, third, and fourth harmonics of the fundamental; sidebands at the difference frequencies between fundamental and chopping; chopping-frequency harmonics; and, to a lesser extent, sidebands due to harmonics of the chopping frequency around the harmonics of the fundamental.

It was also found that voice quality deteriorated as chopping rate increased, although transients caused by sudden stops/starts of modulation seemed to have little effect.

Changes in the Guard Bandwidths had no effect on intelligibility, even though a large number of high-order distortion products were observed.

Significant distortion was noticed due to the squelch tone (150 Hz) and its cross products, which combine with the chopping frequency and the test tone. For expermental purposes, the squelch tone was temporarily eliminated. The output test point of the tone-generator module in the originating Transmitter was wired to a spring clip with insulated brass foil, then grounded. This stopped the 150-Hz tone, and automatically removed all its associated components from the Repeater-Receiver output. Listening tests showed the advantage of this inhibition.

5.2.4 Output Blanking vs. Intelligibility

Output blanking at the Remote Receive Terminal was experimented with, to determine the effect of blanking the noise period corresponding the Repeater receiving period. Intelligibility seemed to improve, and the sound was more pleasant because of the lack of interspersed noise. The effect was most effective at the slower chopping rates.

Blanking was then reduced somewhat, and a small amount of noise was allowed to pass during the blanking period. This improved the intelligibility, and lessened the abruptness of the speech, as though a natural bridge had occurred between chopped bits.

Blanking in the laboratory was done by wire line, for simplicity. In practice, it could be accomplished with an attachment to the appropriate AUDIO Connector on the Remote AN/PRC-25 Receiver.

5.2.5 Moving-Coil Headphones

Listening tests made with moving-coil headphones instead of the existing Handset showed a striking improvement in output quality and intelligibility. However, these phones restored much of the low-frequency response lost in the Handset, resulting in a strong 150-Hz squelch tone and its attendant cross products.

Although not attempted during the tests, the possibility exists of trapping out the squelch tone in the Retransmitter. Suppressing the tone and, therefore, the cross products, would permit increasing the voice-modulation level to the Retransmitter, a decided advantage.

5.2.6 Simulation of Field Operation

The intent of this test was to simulate maximum distance between one link at a time, to determine the effects of noise on each link. First, the originating Transmitter sent out a weak signal while the second link remained normal; then the originating Transmitter sent out a strong signal, while the Retransmitter radiated weak signals. The SNR in each case was 13 dB, using a 1-kHz test tone over the impaired link. (The 13 dB was measured when the link was not chopped: Chopping greatly degrades performance.) The results from this test indicated that distortion due to noise was greatest when the signal on the originating link was the weak one.

6. MAINTENANCE

6.1 GENERAL

The only routine maintenance required by the Repeater is to oil the Tape-Deck mechanism in accordance with the instructions given in the Appendix.

Periodic checks should be made of the BA-386 batteries. They have a tendency of swell once they are discharged, making for difficult removal.

Several types of transistors have been used in the Repeater circuits. However, where an npn must be replaced, 2N585, or similar type transistors may be used without need for selection or matching. The phase comparator and the negative power regulators use 2N404 germanium pnp types. These can be replaced by almost any other similar TO packaging.

Similarly, the diodes aren't critical, and the silicons can be replaced with other similar silicons. Zeners must be replaced by those whose parameters are within 0.5 V of the originals. Slight adjustment to the squaring-circuit symmetry might be necessary if voltage changes occur due to replacement (some asymmetry is not always detrimental).

6.2 TROUBLE LOCATION

A series of scope shots was taken, with the intent of showing the waveforms to be expected at meaningful points in the Control Circuits. When making checks for trouble location, do not use the Alternate Sweep Mode on the scope, as phase relationships can be lost.

Fig. 13 shows the different master-oscillator (chopping frequency) outputs at 30 Hz. The top trace is the sine wave output (about 4 V p-p). The middle trace is the squared-up sine wave fed to the Tape-Deck Modulator. It shows a higher-frequency component added to the negative half cycle; this is merely leakage from the 6-kHz oscillator, and is negligible since there is a large margin of safety in the modulation process (roughly only the center of the wave is used). The asymmetry is due to the GUARD BAND Control being set fully clockwise, to show its effect. Tone bursts fed to the Tape Deck coincide with the positive periods.

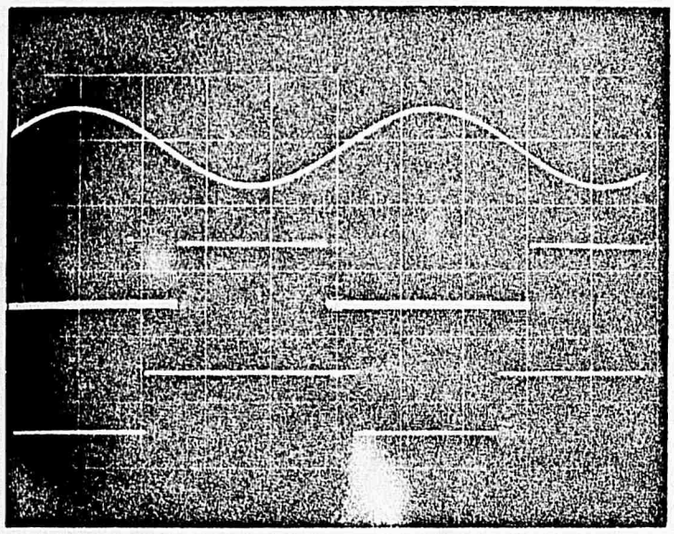

Figure 13. Master-Oscillator Output Waveforms

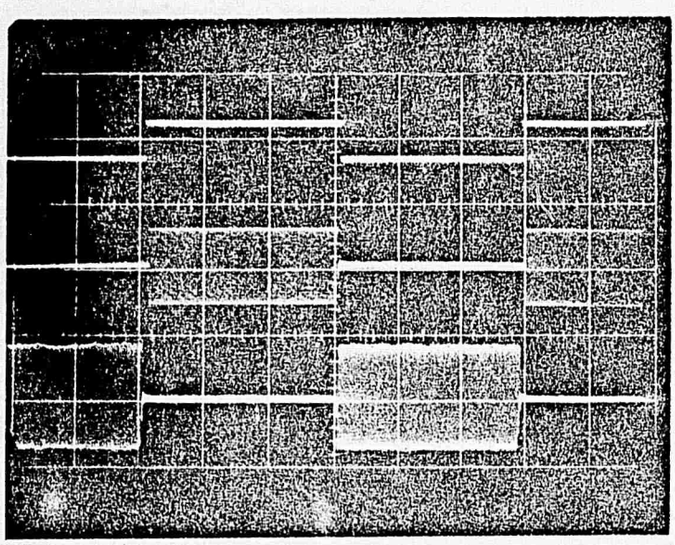

Figure 14. Tape-Deck Control-Channel Input and Output Waveforms

The bottom trace is the output of the Antenna Switch driver (Fig. 7), and is an inverted version of the middle trace. The Retransmitter is turned "on" during the negative half cycles, and the Antenna is simultaneously connected to the Retransmitter and disconnected from the Receiver.

Checks made of these waveforms must result in the same pattern shown in the figure, or trouble is indicated.

Fig. 14 shows the input to and output from the Tape-Deck Control-Signal Channel. The upper trace represents the square-wave modulation to the 6-kHz oscillator. The middle trace is the modulated 6 kHz fed to the Tape Deck. The peculiar waveform is due to the scope's chopper circuit. The bottom trace is the Tape-Deck output. The servo is locked up, and the 180° shift is seen clearly. The scope chopper was "off". Good alignment is seen, and the modulation is clean. The slight ripple shown is due to the tape itself, and is negligible. To have any degrading effects, dropouts must be much more severe and persistent, due to the large safety factor in the recovery circuit. Modulation rate shown is 30 Hz, but results are independent of rate.

Fig. 15 shows input to and output from the Tape-Deck Voice Channel. The upper trace represents the square-wave modulation to the 6-kHz oscillator. The middle trace represents the voice input from the Receiver, and shows a 1-kHz test tone, with 10-kHz deviation, alternated with Receiver noise. The Receiver is connected to the Antenna only during the positive half-cycles, hence the signal is received as shown. The bottom trace represents the voice input to the Retransmitter with the servo locked up. It shows a small overlap of bursts due to improper setting of the GUARD BAND Control.

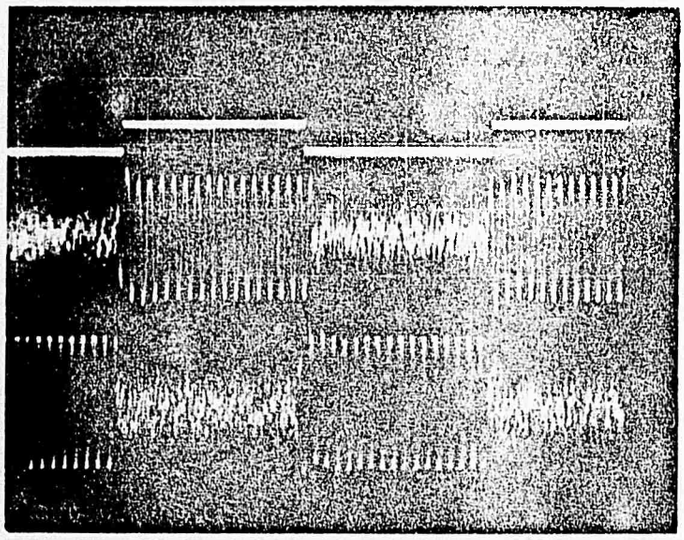

Figure 15. Tape-Deck Voice-Channel Input and Output Waveforms

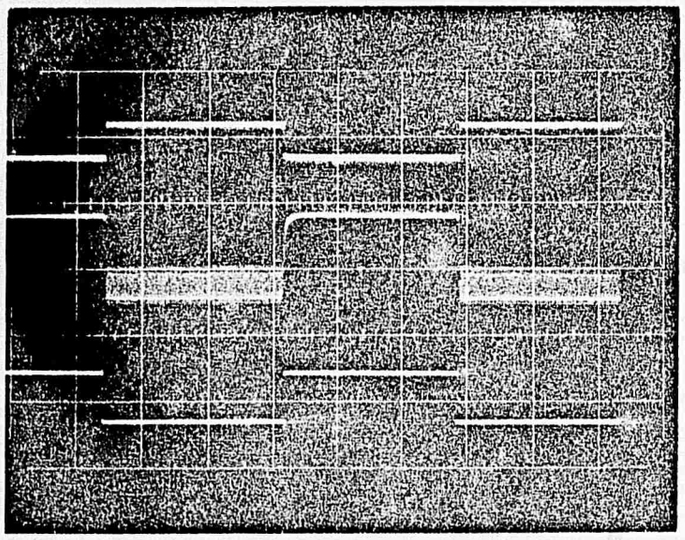

Figure 16. Recovered Servo-Control Input to Phase Comparator

The setting actually made the guard band negative, i.e., the Retransmitter is on for more than a half-cycle, theoretically undesirable. In practice, however, the difference between a slight-overlap condition and a perfect half-on/half-off condition is inaudible. The DC component seen at the start of each Receive period is harmless, and gets lost in subsequent couplings anyway. Second-harmonic distortion is about normal for 10-kHz deviation.

Fig. 16 shows the recovered servo-control signal fed to the phase comparator. The upper trace is, again, the square-wave input to the 6-kHz oscillator. The middle trace is the full-wave-rectified version of the Tape-Deck modulated output (bottom trace of Fig. 14). Considerable residual 6-kHz carrier can be seen during the burst period, but is negligible since only the middle of the wave is used for squaring. (The Tape System is not running here; hence, no 180° phase shift as in Fig. 14.) The bottom trace repeats the phase-comparator output (inverted). Here T.P. Green #3 is grounded to eliminate the 90°-lag wave from the picture. Good alignment is seen between original square wave, and the final recovered and normally-delayed replica.

Fig. 17 shows the progress of the 90°-lag wave (quadrature component) at different points. The upper trace again represents the square-wave input to the 6-kHz oscillator. The middle trace is the master-oscillator sine wave after its 90° shift. Its phase lags as it enters the amplifier, but appears to lead due to the 180° shift in the amplifier stage. The bottom trace is the squared-up version of the sine wave as seen at the output of the Schmitt Trigger.

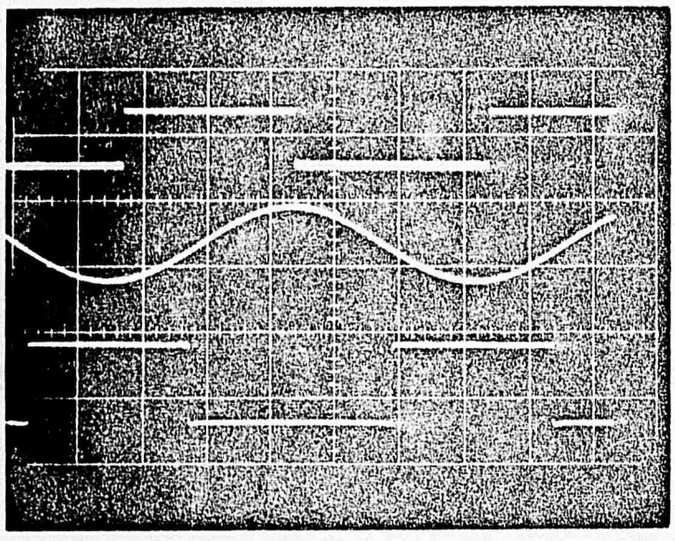

Figure 17. Quadrature-Component (90°-Lag) Waveform

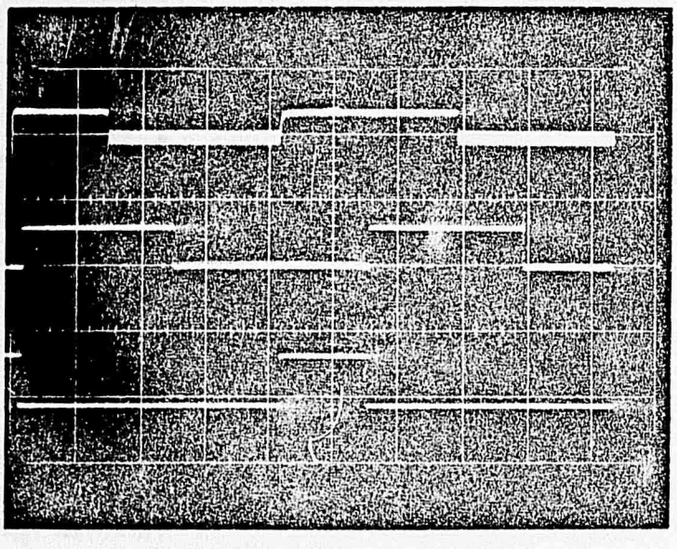

Figure 18. Phase-Comparator Waveforms

Fig. 18 shows phase-comparator action. The upper trace represents the unsquared version of the recovered and delayed control signal shown as the bottom trace in Fig. 16. The middle trace is the squared-up version of the 90°-lag wave (quadrature component). The bottom trace is the phase-comparator output prior to averaging. It represents a one-quarter-duty-cycle output, which is correct whether or not the tape is running. (If the tape is not running, input phase relations are fixed, if running, servo automatically adjusts tape speed until this condition is reached). When the Repeater is operating, mechanically-caused tape-speed variations result in some jitter in the output pulse width. This is unimportant because the servo loop response has deliberately been made too slow to follow such jitter. The pulse should be as shown; if not, there might be excess output from the Tape-Deck Control Channel. Pulse behavior shows servo-loop action clearly.

Fig. 19 is a combination of traces. The upper trace is, again, the square-wave input to the 6-kHz oscillator. The middle trace is the squared-up 90°-lag (quadrature component). The bottom trace represents the multivibrator output wave used to control the DC-to-AC Converter. The relationship between the bottom trace and the other two is very indirect.

7. CONCLUSIONS

The results of the work done so far indicate that Single-Frequency Repeating can be used to repeat a voice-modulated, FM, RF signal and still retain some measure of intelligibility at the Receiving Terminal.

The distance to which the effective range of a pair of AN/PRC-25 Radio Sets can be extended, using the model Repeater is not yet known, mostly because of insufficient performance measurements. Considerable extension is unquestionably possible if the modified AN/PRC-25 Retransmitter is replaced with a suitable Retransmitter.

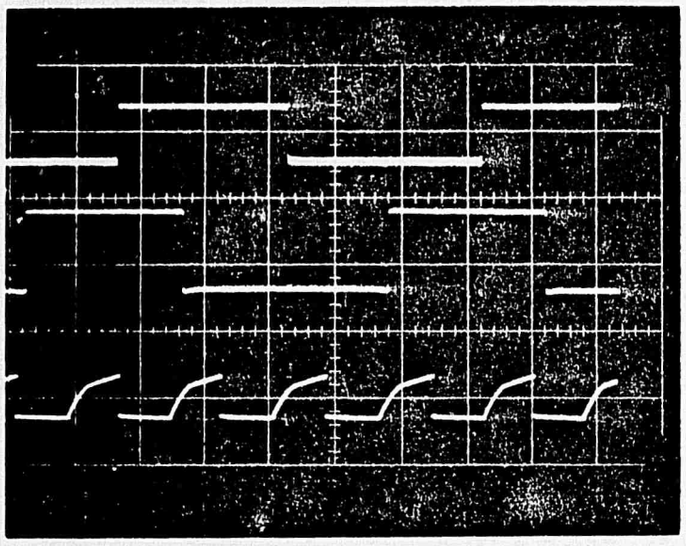

Figure 19. Master-Oscillator, Quadrature-Component, and Multivibrator-Output Waveforms

Some improvements to intelligibility can also be made, as evidenced by the limited experiments already carried out. One, for example, would be to implement synchronous audio blanking at the Remote Receiver during idle (non-transmit) times, thus eliminating the inevitable Receiver noise. Another would be to improve the quality of the audio input to the Retransmitter; it presently suffers from severe distortion. For example, an AGC amplifier used in place of the existing limiting arrangement would certainly offer significant improvement. Still other improvements could accure from optimizing the chopping rate, Guard Band, and the AF responses at both the Repeater and Remote Receivers.

The improvement to intelligibility resulting from implementation of one or more of the foregoing is difficult to estimate at present. A much better assessment could be made after a full system analysis has been performed.

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APPENDIX

SONY®

STEREO TAPERECORDER TC-350/TC-350C

OWNER'S INSTRUCTION MANUAL

Technical Specifications

Power requirements: 50 watts, 117 volts, 60 cycles AC

Tape width: ¼ inch

Reels: 7 inches or smaller

Tape speed: Instantaneous selection 7½ ips. or 3¾ ips. (19 or 9.5 centimeters per second) with automatic equalization change

Recording system: 4-track stereophonic or monophonic

Frequency response: 30 – 20,000 c/s at 7½ ips.
±3 db 50 – 15,000 c/s at 7½ ips.
30 – 14,000 c/s at 3¾ ips.

Signal-to-Noise ratio:

tape speed	peak record level to unweighted noise
7½ ips.	50 db or better
3¾ ips.	50 db or better

*The peak record level is defined as that level at which the overall (input to output on 'line output jack') total RMS harmonic distortion does not exceed 3% when measured on a 400 cycle tone. Noise is measured by playing an erased portion of the tape, on which a signal of peak recording level was present prior to erasure. This will produce the overall figure of noise, including the bias and erase noise, as well as record and playback amplifier noise.

Flutter and wow:

tape speed	
7½ ips.	less than 0.17% RMS
3¾ ips.	less than 0.25% RMS

*The flutter and wow measurements include all components between 0.5 and 250 cycles.

Harmonic distortion: less than 3% at 0 db line output

Level indication: two VU meters
record: NAB standard
playback: calibrated to 0 db at 0 db line output

Recording time:

		4-track stereo	4-track monophonic
1,200′ tape	7½ ips.	1 hr.	2 hrs.
	3¾ ips.	2 hrs.	4 hrs.
1,800′ tape	7½ ips.	1 hr. 30 min.	3 hrs.
	3¾ ips.	3 hrs.	6 hrs.

Fast forward and rewind time:
within 4 min. (1,200′ tape)

Inputs: Microphone inputs
Sensitivity: −72 db (0.19 mV)
Impedance: low (will accommodate any microphone from 250~ 1 K ohm impedance)

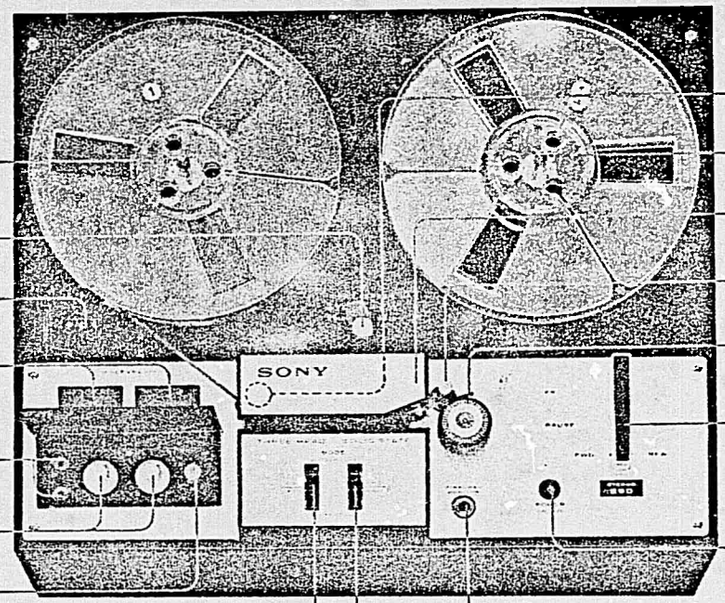
Auxiliary inputs
Sensitivity: −22 db (0.06V)
Impedance: approx 100 K ohms

Integrated record/playback connector
Sensitivity: −42 db (6.15 mV)
Impedance: approx. 100 K ohms

Outputs:	Line outputs
	Output level: 0 db (0.775 V)
	Impedance: optimum load impedance 100K ohms
	Binaural monitor jack
	Output level: −1 db (0.692 V)
	Impedance: accommodates 10K ohm headset
	Integrated record/playback connector
	Output level: 0 db (0.775 V)
	Impedance: optimum load impedance 500K ohms
Heads:	Recording head RP 30-2902
	Playback head PP 30-4202N
	Erase head EF 18-2902H
Transistors:	2SC402×18
	2SB381×2
	2SC291×1
Diodes:	1T22A×2
	5G-D×2
Dimensions:	15⅞(w)×6¾₆(h)×13(d)″...model 350
	18¹³⁄₁₆(w)×7¹³⁄₁₆(h)×16⅞(d)″...model 350C
Weight:	17 lb 3 oz...model 350
	26 lb 7 oz...model 350C

Table of Contents

Diagram of Controls and Connectors



1 FEED REEL SPINDLE
2 TAPE SPEED SELECTOR (TAPE SPEED)
3 TAPE COUNTER
4 VU METERS (LEVEL)
5 MICROPHONE INPUT JACKS
6 RECORD LEVEL CONTROLS (REC. VOL.)
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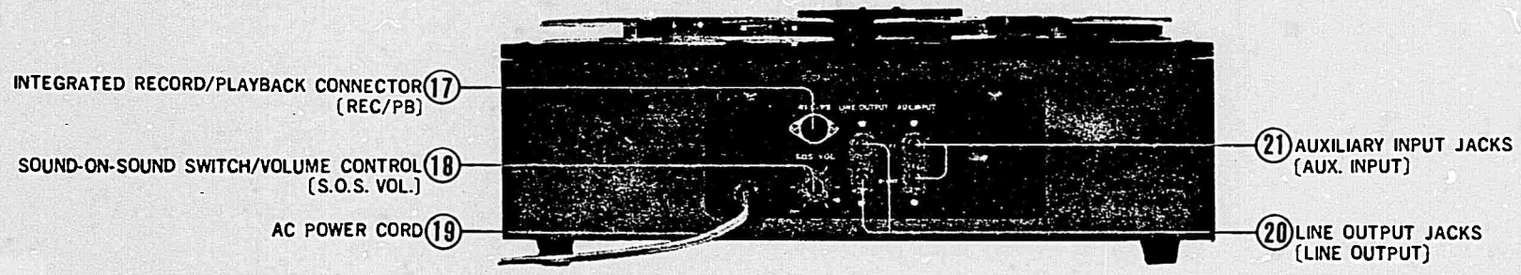
12 PINCH ROLLER
13 CAPSTAN
14 HEAD COVER
15 TAKE-UP REEL SPINDLE
16 AUTOMATIC SHUT-OFF SWITCH

Refer to OPERATION of CONTROLS on page 5 ~ 8.



Refer to INPUT AND OUTPUT CONNECTORS on page 8 ~ 10.

Operation of Controls

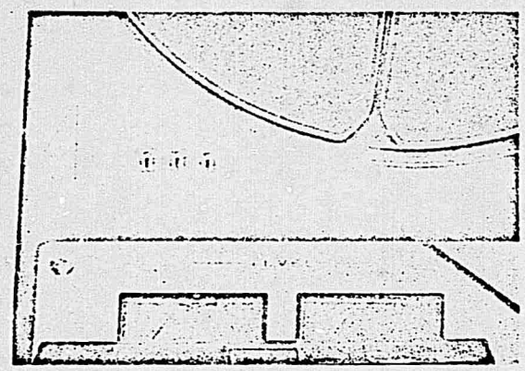
① FEED REEL SPINDLE

② TAPE SPEED SELECTOR [TAPE SPEED]

Selects tape speed of either 7½ ips. (when better sound quality is desired) or 3¾ ips. (when longer recording time is desired). To change from 3¾ ips. to 7½ ips., press down on the speed selector knob and turn clockwise to 7½ ips. position.
To change from 7½ ips. to 3¾ ips., turn the knob counterclockwise and allow the knob to rise.

③ TAPE COUNTER

Indicates the amount of tape used in either record or playback. To reset the tape counter, rotate reset wheel, located to the left of numbers, upward until three zeros [000] appear in the window.



④ VU METERS

Indicates the level of signal being recorded or playback according to the position of the MODE SWITCHES ⑧.
When the MODE SWITCH is set in [SOURCE] position: these meters are calibrated to NAB standard allowing the maximum recording level without distortion.
For best recording results, the RECORD LEVEL CONTROLS ⑥ should be adjusted so that the deflection of the VU METER needle does not continuously remain in the red zone. It is normal for occasional transient peaks to deflect the needle into the red zone.
When the MODE SWITCH is set in [TAPE] position: the tape being recorded can be monitored while the recorder is in RECORD mode. For playback these meters are calibrated so that the needle points to the boundary of red and black zones when the line output level, is approx. 0 db (0.775 V).

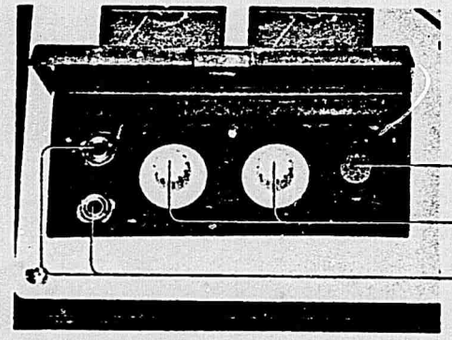
⑤ MICROPHONE INPUT JACKS [MIC]

See page 8, INPUT AND OUTPUT CONNECTORS.

⑥ RECORD LEVEL CONTROLS [REC. VOL.]

Controls level of signal being recorded.
The knob marked [LEFT] is for left channel (CH-1) and the knob marked [RIGHT] is for right channel (CH-2). To increase turn clockwise and to decrease turn counterclockwise. When turned fully counterclockwise to [OFF] position with a click, bias and erase currents to the respective channel are shut off, thus making possible 4-track monophonic recording.

NOTE: These controls have no effect upon playback level.



⑦ RECORD BUTTON

Activates RECORD mode switch.

While pressing the button, turn the FUNCTION SELECTOR to [FWD] position; the tape motion will start and red lamps in the VU METERS will illuminate indicating that the recorder is in RECORD mode.

NOTE: when the FUNCTION SELECTOR is set to [STOP] position, the RECORD BUTTON will be released and the recorder will automatically switch from record to playback.

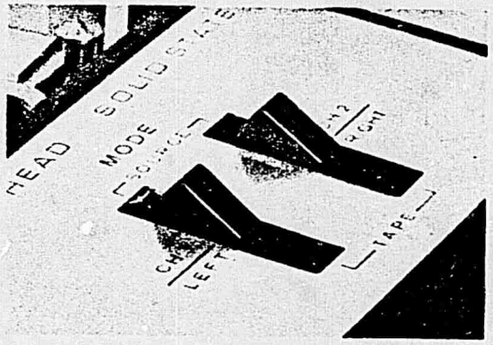
⑧ MODE SWITCHES (MODE)

Has two positions: [SOURCE] and [TAPE].

[SOURCE] The input program source is connected to LINE OUTPUT JACKS ⑳, output of INTEGRATED RECORD/PLAYBACK CONNECTOR ⑰ and BINAURAL MONITOR JACK ⑨.
The VU METER needle deflection shows the level of the input program source. With this feature, the recording level can be previously adjusted without pressing RECORD BUTTON.

[TAPE] For playback, set the switches to this position The deflection of the VU METER needle shows the playback level.

For instantaneous tape monitoring while recording. set the switches to this position.



⑨ BINAURAL MONITOR JACK (BINAURAL MONITOR)

See page 8, INPUT AND OUTPUT CONNECTORS.

⑩ POWER ON/OFF SWITCH (POWER)

Press to turn the recorder ON. The button is locked and the lamp illuminates. Press again to turn OFF.

⑪ FUNCTION SELECTOR

Has five positions of Fast Forward [F.F], Pause [PAUSE], Forward [FWD], stop [STOP] and Rewind [REW].

[F.F] For fast forward tape motion.
The tape motion can be stopped by turning the FUNCTION SELECTOR to [PAUSE] or [STOP] position.

[PAUSE] To momentarily stop tape motion either in record or playback mode. 'Pause' is effective for both normal or fast forward tape speed motions. To return to recording or playback again, simply turn the selector to [FWD] position.

〔FWD〕 To move the tape at normal tape speed for recording or playback.

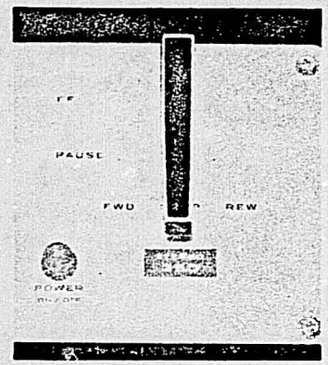
NOTE: While recording, if the selector is set to 〔STOP〕 position, the recorder will automatically switch from record to playback mode.

〔STOP〕 To stop the tape motion.
Always keep the selector in 〔STOP〕 position, when the recorder is not in use.

〔REW〕 To rewind the tape.

NOTE: a. Change from 〔REW〕 to 〔FWD〕 (or vice versa) must be made by bringing the tape to a complete stop in 〔STOP〕 position.

b. Change from 〔F.F〕 to 〔FWD〕 must be made by bringing the tape to a complete stop in 〔PAUSE〕 position.



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⑫ **PINCH ROLLER**

⑬ **CAPSTAN**

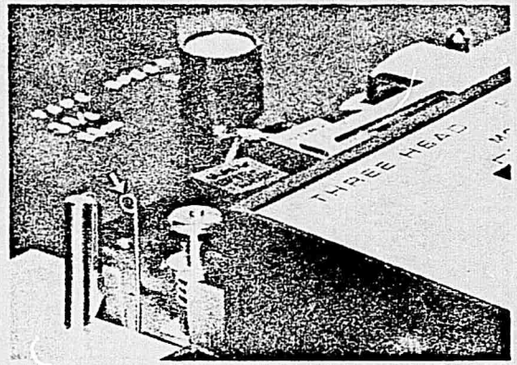
⑭ **HEAD COVER**

Protects heads. When cleaning the heads. remove the cover by pulling it up.

⑮ **TAKE-UP REEL SPINDLE**

⑯ **AUTOMATIC SHUT-OFF SWITCH**

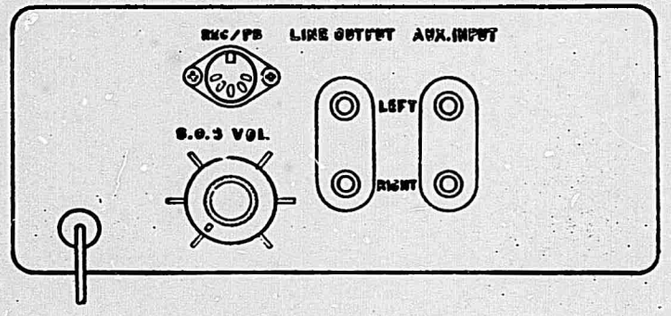
This switch is controlled by a wire lever located under the head cover. In 〔STOP〕 position the shut-off lever recedes into a slot to facilitate easy tape threading. After tape is threaded and the mechanism is placed in either Forward 〔FWD〕, Fast forward 〔F.F〕 or Rewind 〔REW〕 mode, the shut-off lever contacts the tape and is held in this position.
At such time as the tape either runs out or breaks, the lever will automatically fall forward and activate a micro switch which stops tape motion; however, the internal amplifiers are still ON.



⑱ SOUND-ON-SOUND SWITCH/VOLUME CONTROL [S.O.S. VOL.]

Activates sound-on-sound record mode and also controls left channel (CH-1) playback level for composite recordings. For sound-on-sound recording, turn the knob clockwise from [OFF] position and adjust the volume level.

IMPORTANT: Be sure the S.O.S. SWITCH/VOLUME CONTROL is turned off when this facility is not being used.



Input and Output Connectors

⑤ MICROPHONE INPUT JACKS [MIC]

These mini jack inputs are located at the left side of the front panel and accept any high quality low impedance microphone. The low impedance SONY F-96 microphones available as optional accessories are recommended.

The jack marked [L] is for left channel (CH-1) and the jack marked [R] is for right channel (CH-2).

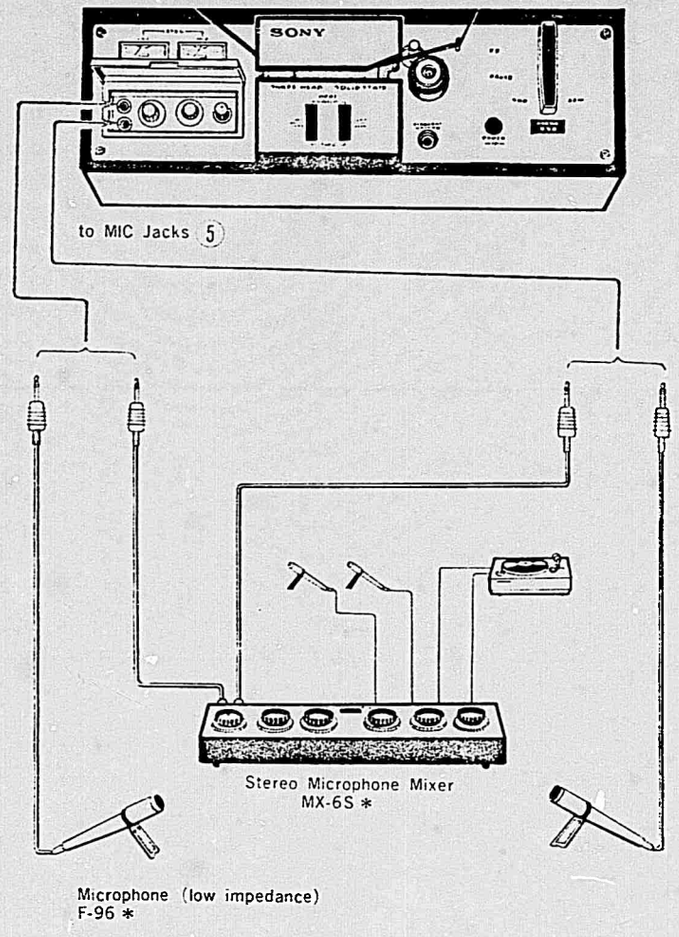
NOTE: When recording with a microphone, howling sounds (acoustic feedback) may occur if the microphone is too near the speakers. In this case, reduce the speaker volume or turn the speaker switch off.

These inputs can also be used with a telephone pickup SONY model TP-4S (optional), stereophonic microphone mixer SONY model MX-6S (optional) for microphone and line mixing, SONY radio equipped with a recording jack, and record player equipped with a magnetic phono cartridge by using SONY Magnetic Phono Connecting Cord model RK-66 (optional).

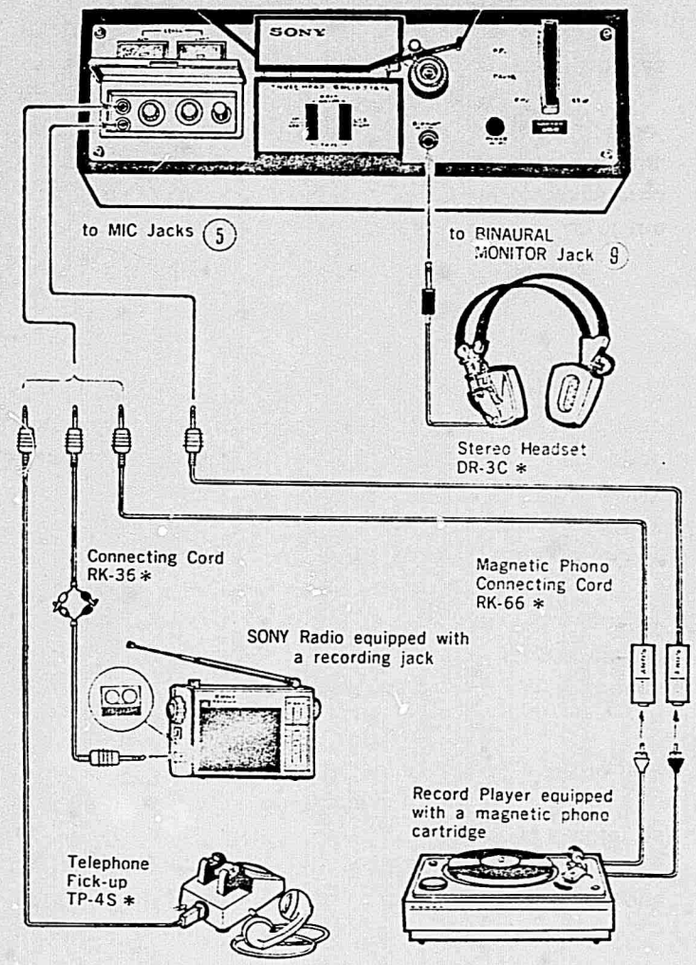
⑨ BINAURAL MONITOR JACK [BINAURAL MONITOR]

A standard binaural phone jack is located at the center of the front panel. This output connects to any high impedance stereo headset which is equipped with a standard binaural phone plug. It enables stereo headset monitoring of either 'source' or 'tape' when used in conjunction with the MODE SWITCHES⑧.

Ideal headset is the SONY model DR-3C, which is available as an optional accessory.



Accessories marked (*) are available separately



Accessories marked (*) are available separately

⑰ INTEGRATED RECORD/PLAYBACK CONNECTOR [REC/PB]

The 5-pin socket is used for interconnection of inputs and outputs of the recorder to an amplifier that incorporates a matching socket.

Use the single cable SONY REC/PB Connector Cable model RC-2 (optional) for connection. No additional connection is required.

NOTE: While recording by connecting this REC/PB connector, the outputs of this connector are disconnected.

⑲ AC POWER CORD

Connects to a 117V AC outlet of the household power line.

⑳ LINE OUTPUT JACKS [LINE OUTPUT]

These phono jack outputs connect to tape recorder inputs of an integrated amplifier.

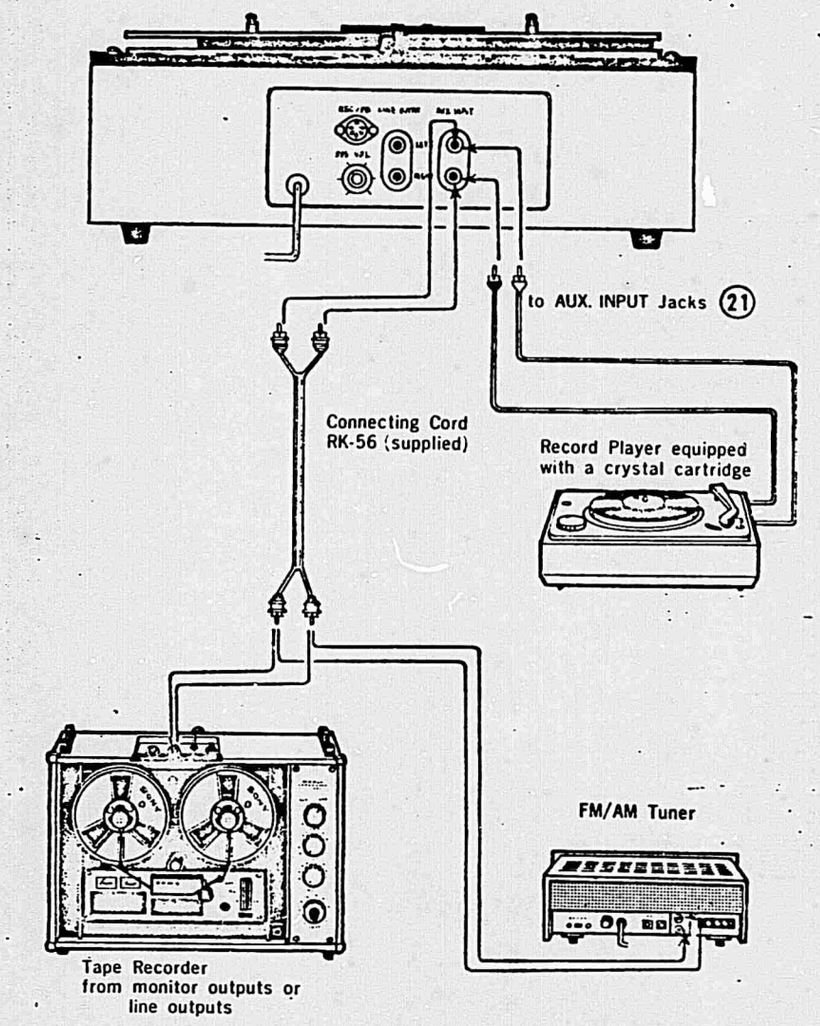
Use SONY Connecting Cord RK-56 (supplied) for connection.

㉑ AUXILIARY INPUT JACKS [AUX. INPUT]

These phono jack inputs are high impedance and will accept recording outputs from an integrated amplifier.

Use SONY Connecting Cord RK-56 (supplied) for connection. These inputs can also be used for connection to FM/AM tuner, tape recorder, record player equipped with a crystal cartridge for recording directly from the connected components.

NOTE: When the MICROPHONE INPUTS ⑤ are used, these inputs are automatically disconnected.



How to connect the recorder to an integrated amplifier

Connect left (CH-1) and right (CH-2) LINE OUTPUT JACKS ⑳ of the recorder to respective tape input jacks of an integrated amplifier, using the supplied SONY Connecting Cord RK-56. Then, connect left (CH-1) and right (CH-2) AUXILIARY INPUT JACKS ㉑ of the recorder to respective tape output jacks of the integrated amplifier, using the other SONY Connecting Cord RK-56, which is also supplied with the recorder.

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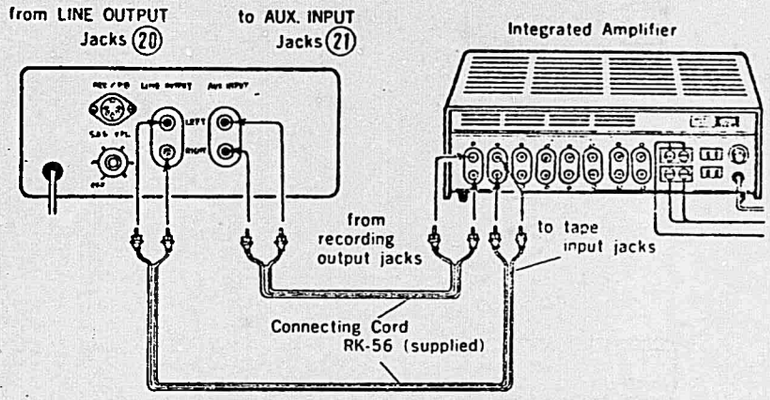
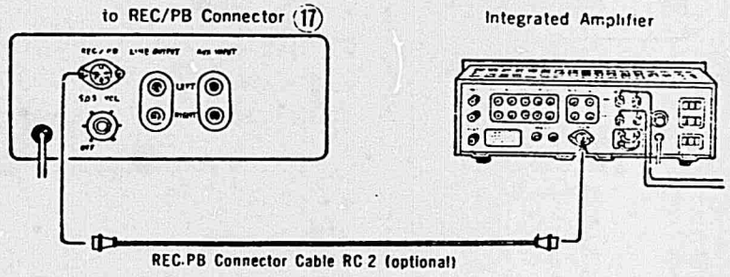


The 5 pin socket designated REC/PB. ⑰ is used for the interconnection of the models 350/350C high level inputs and outputs with an integrated amplifier of foreign manufacture that incorporates a matching socket. A SONY REC/PB Connector Cable RC-2 is available as an optional accessory.

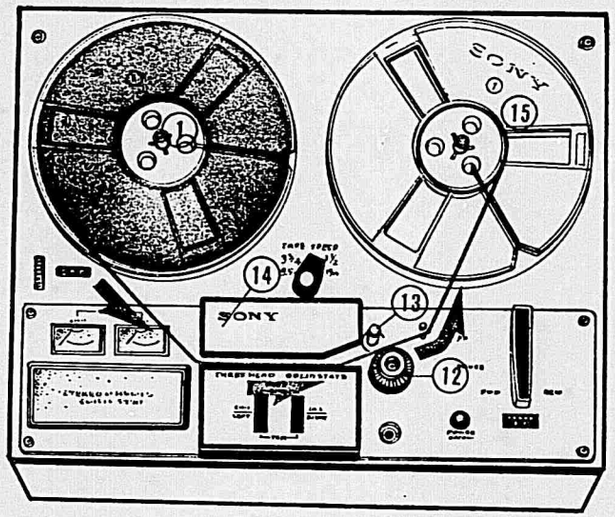


Threading Tape

Reel sizes from 3 to 7 inches in diameter are accommodated. Threading procedure is the same for all reel sizes.

1. Place an empty reel on the TAKE-UP REEL SPINDLE (15) (right). Rotate until the slot of the reel engages the spindle.
2. Place a full reel of tape on the FEED REEL SPINDLE (1) (left) and engage as described in step 1.
3. Unwind approximately 1½ feet of tape or leader from the full reel.
4. Keep unwound portion of tape or leader slightly taut with shiny surface to the outside.
   Bring leader from left to right; through the tape path of the HEAD COVER (14), between CAPSTAN (13), and PINCH ROLLER (12) and around the outside of the guide pin.
5. Wrap it around hub of the empty reel, or insert the end into the slot of the reel.
   Tape is now ready for playing or recording.

NOTE: When the recorder is used in vertical position use rubber reel caps (supplied) to retain the reels on the recorder.



Playing Tapes

To Play Back 4-Track Stereo Tape

1. Place a 4-track pre-recorded tape with side 1 of the tape (tracks 1 and 3) up on the FEED REEL SPINDLE ① and thread the tape. (When the recorder is used in a vertical position, be sure to use both reel retaining caps. Do not use them when the recorder is in horizontal position.)
2. Select tape speed.
3. Set the MODE SWITCHES ⑧ to [TAPE] position.
4. Turn the FUNCTION SELECTOR ⑪ to [FWD] position.
   Now the tracks 1 and 3 are playing.
   (Playback output is obtained without passing through level control of the recorder.)
   Adjustments for obtaining optimum volume level and sound quality should be performed by controls of the external amplifier.
5. When the end of the tape is reached, do not rewind.
6. Invert and reverse the tape reels to playback tracks 4 and 2.
   Place the full reel on the FEED REEL SPINDLE (left) and the empty reel on the TAKE-UP REEL SPINDLE (right).
7. Repeat operation step 4.

To Play Back 4-Track Monophonic Tape

The following playback procedure is recommended for a monophonic tape whose sequence of recording is; track 1 — track 4 — track 3 — track 2.

1. Place a 4-track monophonic pre-recorded tape on the FEED REEL SPINDLE (left) and thread the tape.
2. Select tape speed.
3. Set the left MODE SWITCH ⑧ to [TAPE] position to playback tracks 1 and 4.
4. Set the mode selector and/or other controls of the external amplifier to reproduce the left channel (CH-1) sound.
5. Turn the FUNCTION SELECTOR ⑪ to [FWD] position. Now track 1 is playing.
6. Track 4 will also be played back by simply reversing and inverting the reels.
7. To playback tracks 3 and 2, set the right MODE SWITCH ⑧ to [TAPE] position. Also set the mode selector and/or other controls of the external amplifier to reproduce right channel (CH-2) sound. Then turn the FUNCTION SELECTOR ⑪ to [FWD] position.

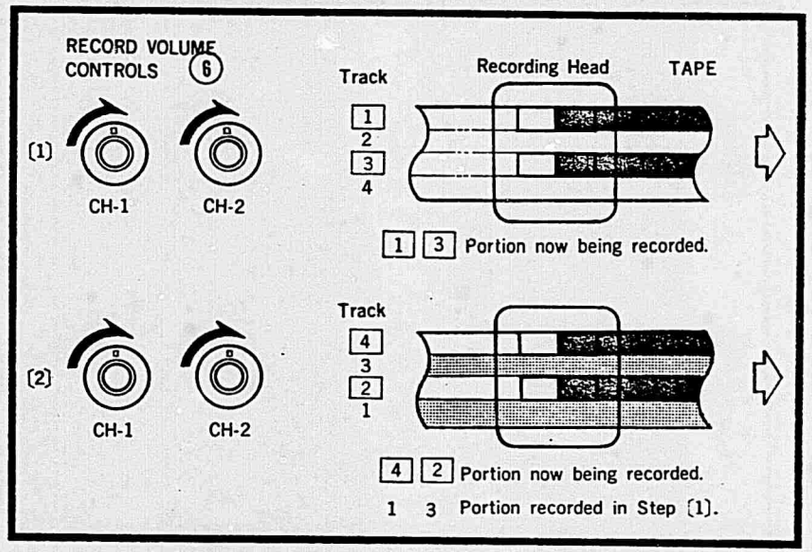
Recording

Before recording, try to estimate the input program playing time and provide more tape on the recorder than you think you will actually need.

NOTE: Be sure to check whether SOUND-ON-SOUND SWITCH/ VOLUME CONTROL ⑱ marked [S.O.S. VOL] which is located on the back panel is in [OFF] position.

4-Track Stereo Recording

1. Thread the tape on the recorder.
2. Select the desired tape speed and reset the TAPE COUNTER ③.
3. Switch the function selector of the connected external amplifier according to the desired input program source for recording.
   *When the recorder is not connected to an integrated amplifier, connected stereo source to proper input jacks of the recorder. (See page 8, INPUT AND OUTPUT CONNECTORS.)
4. Set the MODE SWITCHES ⑧ to [SOURCE] position and adjust recording level by turning RECORD LEVEL CONTROLS ⑥.
   See VU METERS ④.
5. Hold the RECORD BUTTON ⑦ in, turn FUNCTION SELECTOR ⑪ to [FWD] position. The RECORD BUTTON ⑦ is locked and recording on tracks 1 and 3 has started.
6. When the end of the tape is reached, do not rewind.
7. To record tracks 4 and 2, reverse and invert reels.
   Place the full reel on the FEED REEL SPINDLE ① (left) and empty reel on the TAKE-UP REEL SPINDLE ⑮ (right).
8. Thread the tape again and repeat operation steps 4 and 5.



To Monitor While Recording

The professional feature of separate record and playback heads permits the monitoring of the recorded results while recording the same track (or tracks) by setting the MODE SWITCHES ⑧ to [TAPE] position.

When the external amplifier is equipped with a tape monitor switch, instantaneous comparison of the recordings and the recorded results is possible by turning on and off the tape monitor switch of the amplifier. In this case, the MODE SWITCHES ⑧ of the recorder should be in [TAPE] position.

Through the BINAURAL MONITOR JACK ⑨, an instantaneous comparison of the recordings and the recorded results is possible by the setting the MODE SWITCHES ⑧ alternately to [TAPE] and [SOURCE] positions.

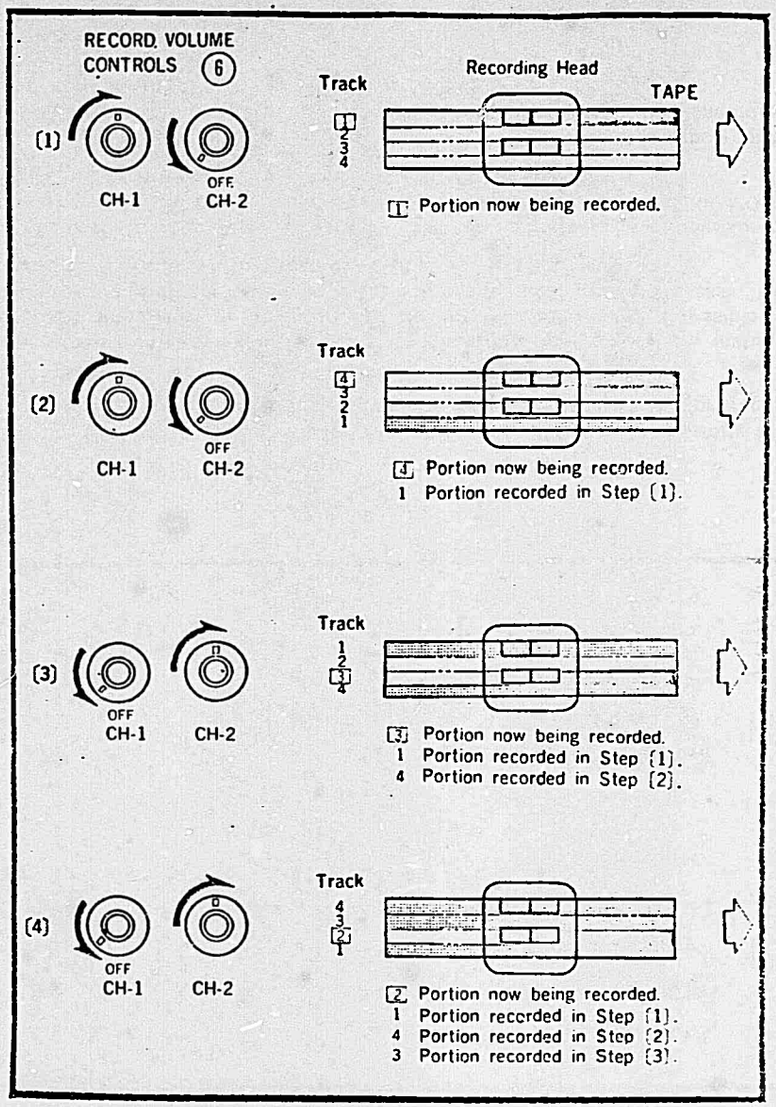
When the REC/PB CONNECTOR ⑰ of the recorder is used and the recorder is set in RECORD mode, the instantaneous tape/source monitoring should be done through the BINAURAL MONITOR JACK ⑨.

4-Track Monophonic Recording

1. Thread the tape on the recorder.
2. Select tape speed and reset the TAPE COUNTER(3).
3. Switch the function selector of the external amplifier according to the desired input program source for recording.
   *When the recorder is not connected to an external amplifier, connect the desired monophonic source to left channel (CH-1) input. (See page 8, INPUT AND OUTPUT CONNECTORS.)
   Turn the right RECORD LEVEL CONTROL (6) fully counterclockwise to the [OFF] position until it clicks.
4. Set both MODE SWITCHES (8) to [SOURCE] position and adjust recording level by turning left RECORD LEVEL CONTROL (6). See left VU METER(4).
5. Hold the RECORD BUTTON(7) in, turn FUNCTION SELECTOR (11) to [FWD] position. The RECORD BUTTON (7) is locked and recording on track 1 has started.
6. When the end of the tape is reached, do not rewind.
7. Reverse and invert reels to record track 4. Place the full reel on the FEED REEL SPINDLE (1) (left) and the empty reel on the TAKE-UP REEL SPINDLE (15) (right).
8. To record tracks 3 and 2, turn left RECORD LEVEL CONTROL (6) fully counterclockwise to the [OFF] position until it clicks. Be sure to check whether the right MODE SWITCH (8) is set in the [SOURCE] position. Adjust recording level by the right RECORD LEVEL CONTROL (6) and right VU METER(4).
9. Repeat operation steps 5, 6 and 7.
   Playback sequence of each track should conform to the sequence of recording, i. e.

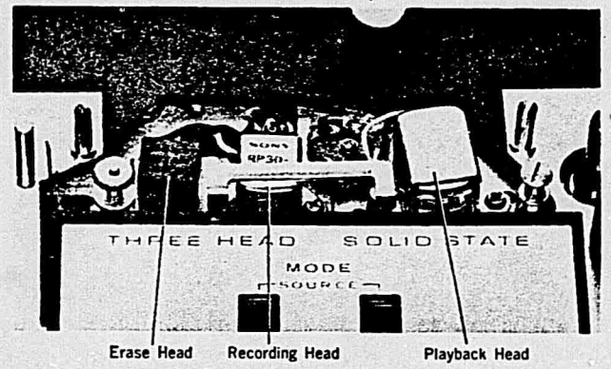
   track 1
   track 4 — left channel (CH-1)

   track 3
   track 2 — right channel (CH-2)

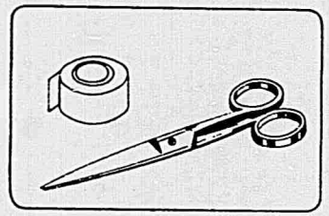


Erasing Tape

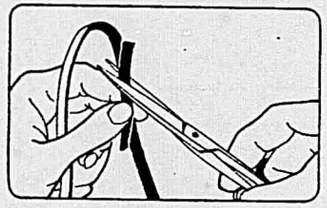
When the recorder is set in the record mode, the Erase Head will erase the track (or tracks) of the tape for the corresponding traces of the recording head. Therefore, when you start a new recording, any previous recordings are automatically erased as the tape passes the erase head.
You can also erase a tape without adding a new recording. Simply place the recorder in record mode by turning left (CH-1) and right (CH-2) RECORD LEVEL CONTROLS ⑥ fully counterclockwise (but not turn off) and run the tape through.
The tape will be erased more quickly by using a bulk eraser.



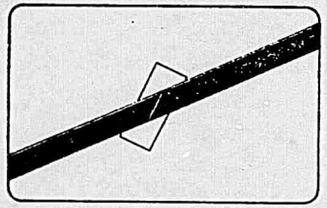
Splicing Tape



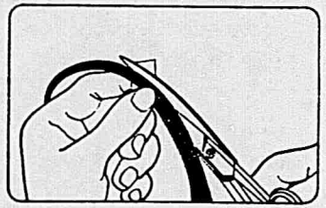
1. Use splicing tape and a pair of scissors.



2. Overlap the recording tapes and make a diagonal cut across both tapes.



3. Carefully align and butt the cut ends together. Keep the ends in contact, firmly press a piece of splicing tape over the shiny side of the tape to make a firm joint.



4 Trim off the excess splicing tape.

Sound-on-Sound Recording

This recorder is equipped to produce high quality professional 'sound-on-sound' composite recordings. A small amount of practice with the following procedures will enable you to become expert in the many facinating uses of 'sound-on-sound' recordings.

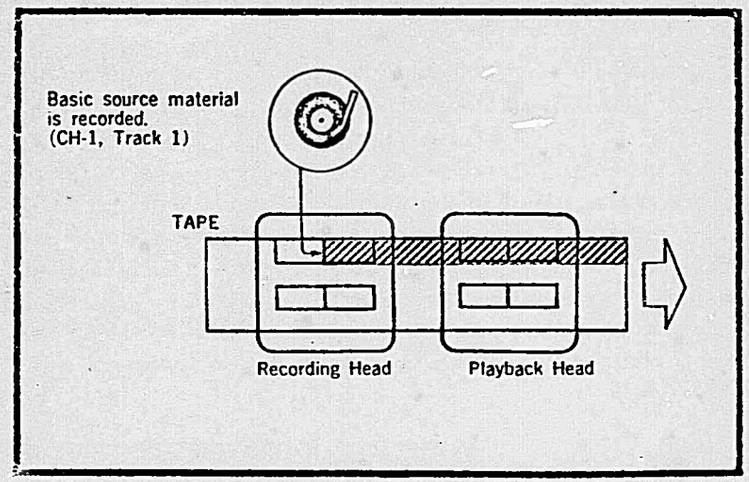
Recording basic source material

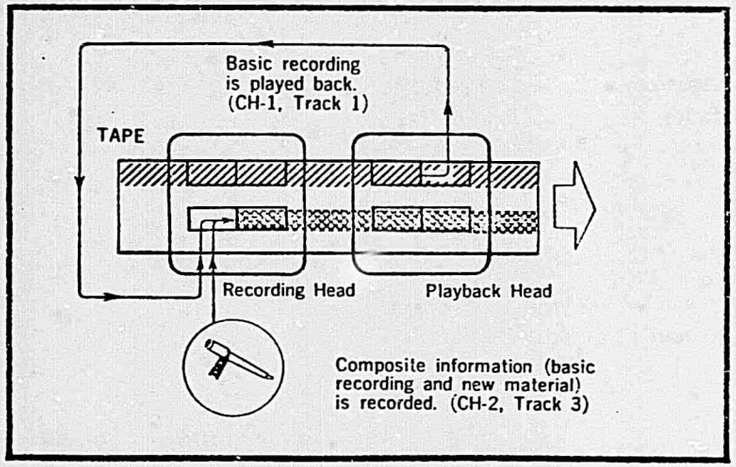
1. Record basic source material on track 1 of the left channel (CH-1), as outlined under 4-track monophonic recording on page 15, and rewind the tape back to the beginning.

Recording composite information

2. Turn off the left (CH-1) RECORD LEVEL CONTROL ⑥ and set left (CH-1) MODE SWITCH ⑧ to [TAPE] position.
3. Turn on the SOUND-ON-SOUND SWITCH/VOLUME CONTROL ⑱ located at the rear side.
4. Plug in the right (CH-2) MICROPHONE INPUT ⑤.
5. Plug in high impedance headset to BINAURAL MONITOR JACK ⑨
6. Listening through the headset, adjust and balance the recording level by rotating SOUND-ON-SOUND SWITCH/VOLUME CONTROL ⑱ and right (CH-2) RECORD LEVEL CONTROL ⑥

NOTE: From the left (CH-1) headset, the playback of left channel (CH-1) is heard and from the right (CH-2) headset, the recorded results of the composite recordings is heard when the MODE SWITCHES ⑧ are set in [TAPE] position.





Left [CH-1] VU METER shows the playback level of the basic source material.

Right (CH-2) VU METER shows the level of the composite recordings being made.

A certain amount settings will insure both signals of the composite track being recorded in desired ratio.

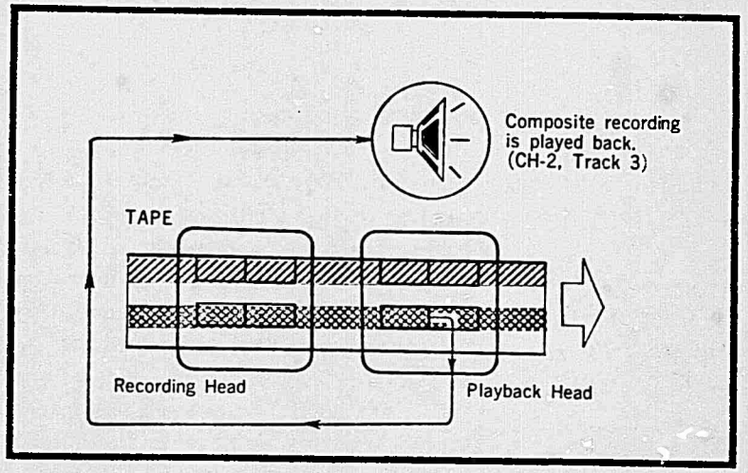
7. When the end of the tape is reached, the composite information will have been recorded on track 3 of right (CH-2) channel.

   NOTE: Sound-on-sound recording is possible only from left channel (CH-1) to right channel (CH-2).

8. Be sure to turn OFF the SOUND-ON-SOUND SWITCH/VOLUME CONTROL (18) when the composite recording is completed.

Playback

9. Rewind the tape back to the beginning and playback recordings on track 3 as outlined under To playback 4-track monophonic tape on page 13.

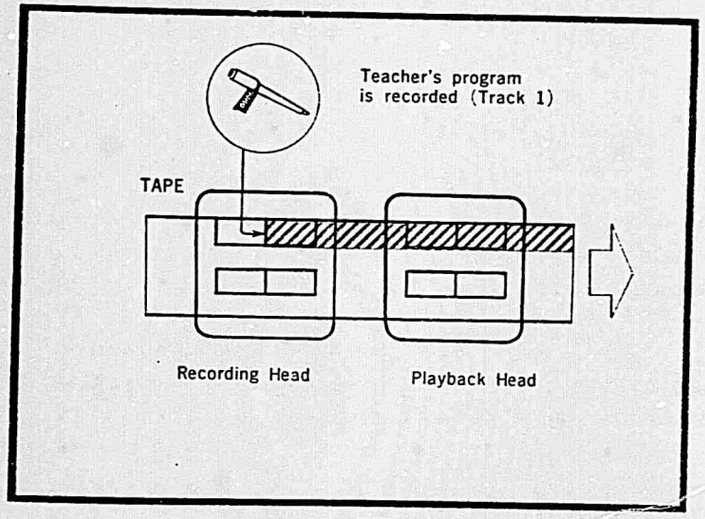


Tape Teaching

This recorder provides facilities to play back one track while the other track is being recorded. This exclusive feature is ideal for language students who wish to listen to a pre-recorded lesson on one track while recording the answers or repetitions on the other track. Both tracks can later be played back separately or simultaneously for comparison.

Master recording

1. Record teacher's program on track 1 (left channel, CH-1) acording to 4-track monophonic recording on page 15, and rewind the tape back to the beginning.



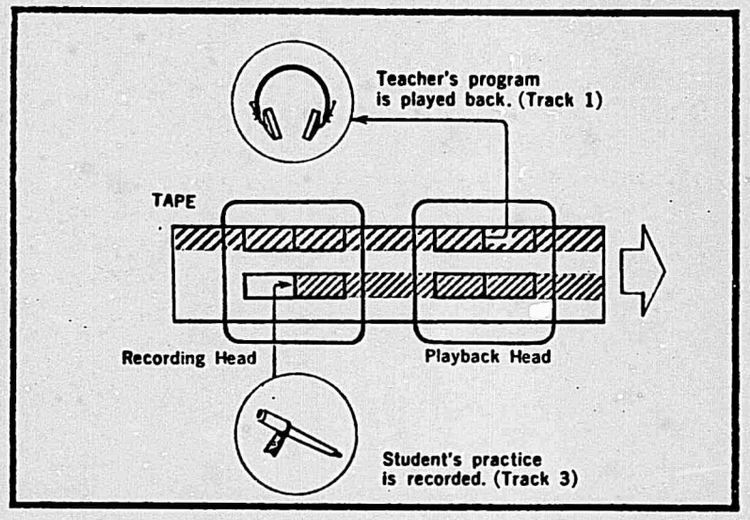
Practice recording

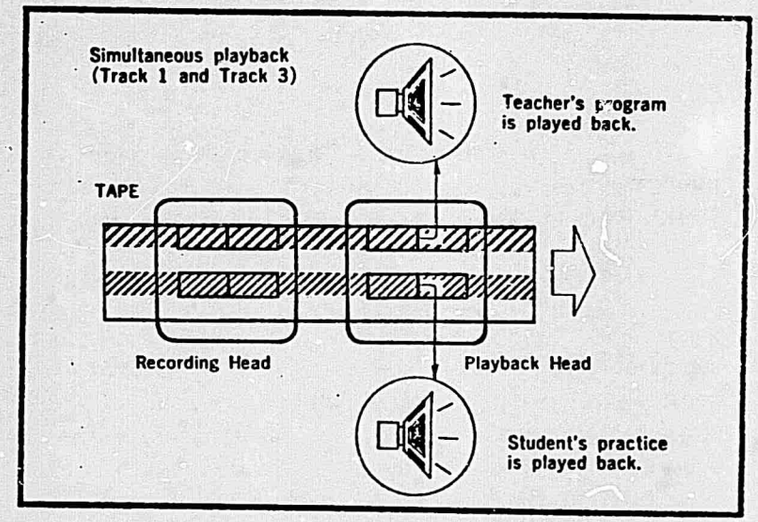
2. Turn OFF the left (CH-1) RECORD LEVEL CONTROL ⑥ and set the left (CH-1) MODE SWITCH ⑧ to [TAPE] position
3. Connect the headset to the BINAURAL MONITOR JACK ⑨.
4. Connect the microphone to the right (CH-2) MICROPHONE INPUT JACK ⑤.
5. Turn ON the right (CH-2) RECORD LEVEL CONTROL ⑥ and record your practice recordings on track 3 (right channel, CH-2) by repeating or answering the master recording which is heard througth the headset.

Simultaneous playback

6. Rewind and playback the tape in the same manner as a stereo tape; then, the master track and the practice track are simultaneously reproduced.

In the above method, the master and the practice recordings are made separately on different channels, so that the practice track can be repeatedly recorded without erasing the master track.





How to Mount Model 350

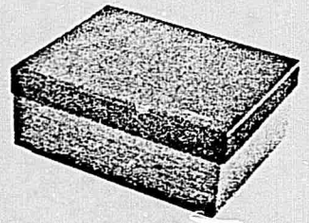
The model 350 can be installed in either horizontal or vertical position.

1. Cut hole of 15 × 11¼ inches in desired mounting location.
2. Remove FUNCTION SELECTOR knob, TAPE SPEED SELECTOR knob, HEAD COVER, RECORD LEVEL CONTROL knobs, PINCH ROLLER and five Philips mounting screws from the top panel and lift up the panel.
3. Remove deck from wooden base by unscrewing (turn counterclockwise) four rubber bases and a screw from the bottom of the wooden base.
4. Mount deck in new location and fasten with three wood screws (supplied).
5. Place the top panel on top of the deck and replace the parts removed in Step 2.

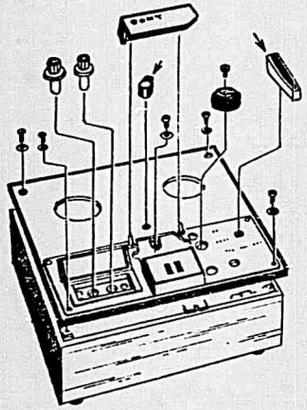
NOTE: The Model 350C cannot be mounted in the above manner and should not be removed from its luggage type carrying case for custom installation. When such an installation is required, the Model 350C should be installed on a shelf or in a recess to permit its removal for portable use.

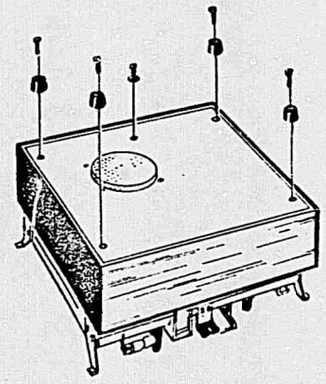
Note on ventilation

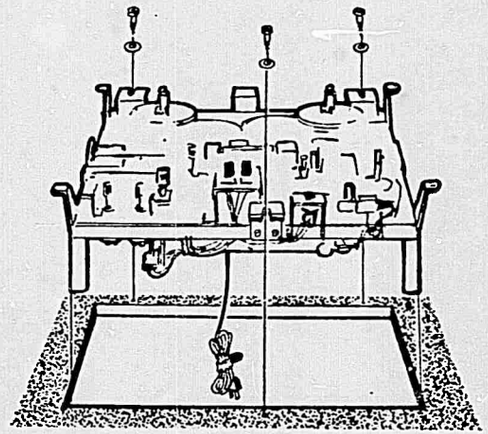
Obstruction of the ventilation grill located on the bottom of the recorder will result in detrimental heat inside the recorder. Do not place ycur recorder on a soft surface such as carpeting, cushions, etc., while operating. This will insure proper ventilation of the recorder.



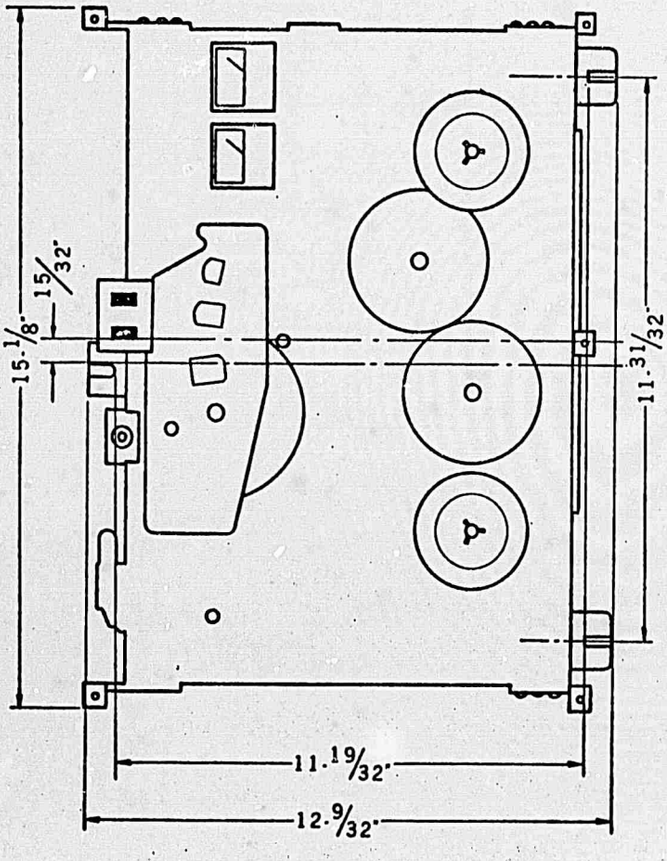
NOTE: When the recorder Model 350 is not in use, use the dust cover supplied with the recorder.
To use the cover, fasten four snaps on the corners o the cover and place it on the recorder.

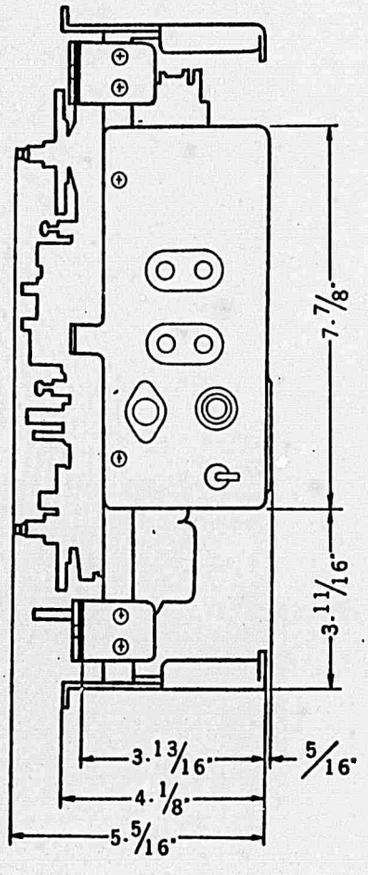






Mounting Dimensions





Maintenance

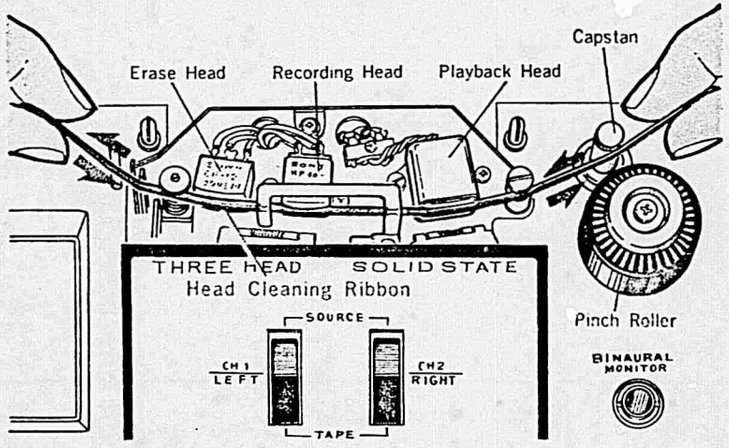
Cleaning heads

Intimate contact between heads and tape is important for optimum performance. Generally, cleaning heads after every ten hours of use will be sufficient.

TO CLEAN

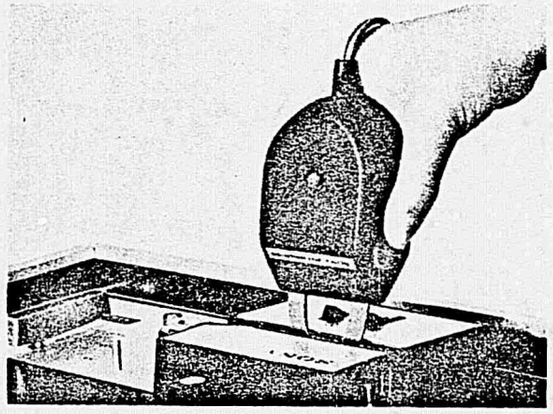
Take the head cleaning ribbon (supplied) and carefully wipe the the portion of the heads over which the tape travels. (In case the deposits on the head cannot be removed, dampen the head cleaning ribbon with denatured alcohol and repeat the cleaning.) The same procedure is recommended for cleaning the capstan and pinch roller surfaces. This prevents oxide deposits from causing flutter and wow.

NOTE: Do not bring magnets or pieces of steel near the heads to prevent heads from magnetizing.

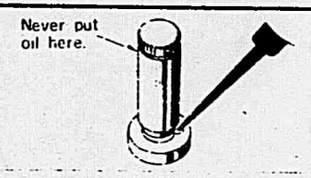
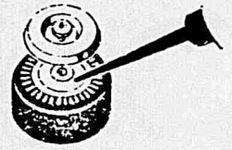
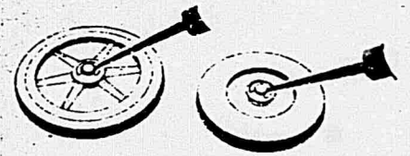
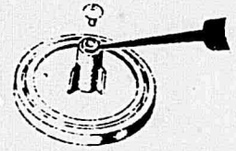


Demagnetizing heads

Through continuous use, the varying magnetic fields of the tape will gradually build up residual magnetism on the gap of the head. Excessive residual magnetism on the head will produce noise while the tape is being played; therefore, it is advisable to demagnetize the heads from time to time. The periodic use of SONY Head Demagnetizer HE-2 (optional) is recommended for the best possible performance.

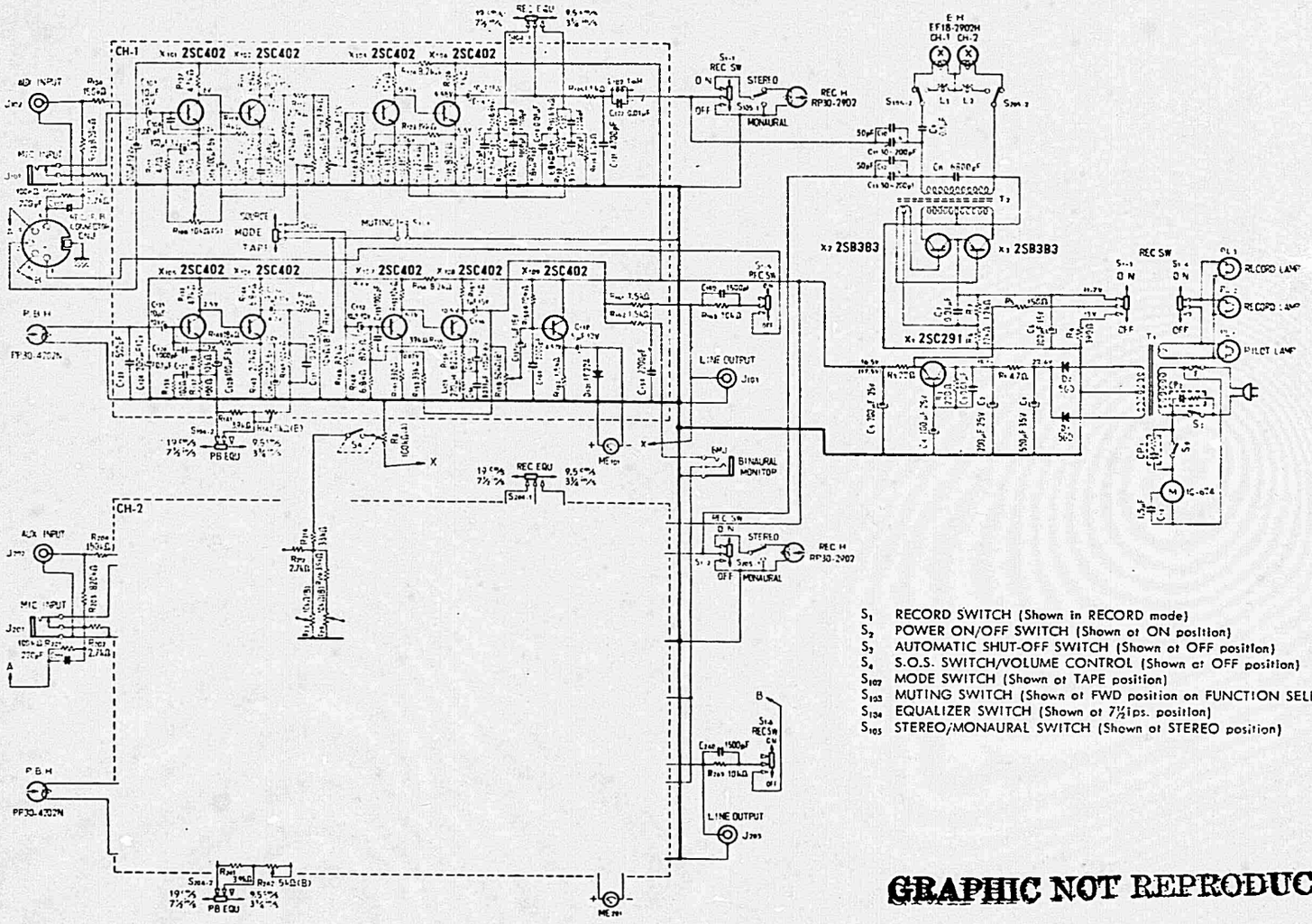


Lubrication chart

Parts to lubricate	Quantity of oil (once for 6 months)	Type of oil	Remarks	Figures
Capstan bearings	3 drops	Light machine oil	Don't stain capstan surface	
Pinch roller bearings	1 drop	Light machine oil	Don't stain rubber surface	
Idler shafts	1 drop	Light machine oil	Remove top cover panel to gain access (see page 20)	
Reel shafts	1 drop	Light machine oil		

NOTE: (1) Avoid excessive lublication. It will cause slippage in the mechanism and contamination of your tape.
(2) If stalling occurs in FAST FORWARD motion, clean each rubber idler wheel under the top panel with a soft cloth moistened with denatured alcohol.

Schematic Diagram



S_1 RECORD SWITCH (Shown in RECORD mode)
S_2 POWER ON/OFF SWITCH (Shown at ON position)
S_3 AUTOMATIC SHUT-OFF SWITCH (Shown at OFF position)
S_4 S.O.S. SWITCH/VOLUME CONTROL (Shown at OFF position)
S_{107} MODE SWITCH (Shown at TAPE position)
S_{103} MUTING SWITCH (Shown at FWD position on FUNCTION SELECTOR)
S_{104} EQUALIZER SWITCH (Shown at 7½ips. position)
S_{105} STEREO/MONAURAL SWITCH (Shown at STEREO position)

GRAPHIC NOT REPRODUCIBLE

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13. ABSTRACT

A study has been made of the feasibility of using a Single-Frequency Repeater for extending the range (voice) of the AN/PRC-25 Radio Set. A feasibility model has been designed using the principle of chopped, delayed voice; constructed; and tested in a limited manner. Test results are presented, as are general description and operating instructions.

The results of the work done so far indicate that Single-Frequency Repeating can be used to repeat a voice-modulated, FM, RF signal and still retain some measure of intelligibility at the Receiving Terminal.

The distance to which the effective range of a pair of AN/PRC-25 Radio Sets can be extended, using the model Repeater is not yet known, mostly because of insufficient performance measurements. Considerable extension is unquestionably possible if the modified AN/PRC-25 Retransmitter is replaced with a suitable Retransmitter.

Some improvements to intelligibility can also be made, as evidenced by the limited experiments already carried out. One, for example, would be to implement synchronous audio blanking at the Remote Receiver during idle (non-transmit) times, thus eliminating the inevitable Receiver noise. Another would be to improve the quality of the audio input to the Retransmitter; it presently suffers from severe distortion. For example, an AGC amplifier used in place of the existing limiting arrangement would certainly offer significant improvement. Still other improvements could occur from optimizing the chopping rate, Guard Band, and the AF responses at both the Repeater and Remote Receivers.

DD FORM 1 JAN 64 1473

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Single-Frequency Repeater Retransmitter Antenna Switch Phase Comparator Servo System Tape Control AN/PRC-25						

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